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The British Mycological Society

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Edited by

CARLETON REA and J. RAMSBOTTOM

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The PRESIDENT and SECRETARY of the Society *ex Officio*.

WINDSOR FORAY.

September 28th to October 3rd, 1923.

By E. M. Wakefield, M.A., F.L.S.

THE twenty-seventh Autumn Foray and Annual General Meeting of the Society was held at Windsor from Friday, September 28th, to Wednesday, October 3rd. The headquarters were at the White Hart Hotel, where a large room was secured for the meetings and exhibition of specimens. Here a large number of species collected in Windsor Forest by some of the earlier arrivals were exhibited. Mr Metcalfe Day brought *Tricholoma psammopum* from Minchinhampton.

On the Friday evening the Council nominated officers and new members of Council for election at the General Meeting on the morrow, and discussed the programme for 1924. Reading, under the guidance of Mr Buddin, was suggested as the locality for the Phytopathological excursion in the summer—the date being left to be considered in connection with the Imperial Botanical Conference.

On Saturday a start was made at 10.0 a.m., and Virginia Water was searched. Specially noteworthy was the great abundance of *Amanita mappa*, this and *Russula ochroleuca* being encountered in quantity. *Amanita phalloides*, on the other hand, was very scarce, both here and elsewhere during the foray. One or two fine specimens of *Sparassis crispa* were found at the foot of some pines near the lake. Some members who had been at the Oxshott day foray in October 1922, and had found there a beautiful pink Discomycete, were extremely interested to meet with the species again here—growing under similar conditions beneath tufts of *Epilobium angustifolium*. The species was collected again on the fourth day of the foray. This was subsequently found to be an undescribed species allied to *Pustularia bolaris* (Bres.) Boud. *Aleuria Emileia* was another find on this day, as well as several rare Agarics.

In the evening the General Meeting was held. Mr Ramsbottom was elected President for 1924, Miss Lister Vice-President, and Messrs W. J. Dowson and C. J. Sharpe to the Council. The other officers were re-elected.

Meetings were arranged as in 1923, that is, three London meetings, a Spring and an Autumn Foray, a Phytopathological excursion, two Students' day forays, and day forays with the Essex Field Club and the British Ecological Society.

As alternatives to Buxton, already suggested for the Spring Foray, Tintern and Salisbury were proposed, but a small majority favoured Buxton.

For the Autumn Foray Sherwood Forest and North Wales were discussed. North Wales, with headquarters at Bettws-y-Coed, was decided upon provided arrangements could be made.

Mr Ramsbottom reported that out of the grant sanctioned at the Keswick meeting he had purchased for the Society Grove's *British Rust Fungi* and that he had arranged for copies of all the British Museum publications on fungi, lichens and mycotozoa to be presented to the Society. Further, Mr Sharpe had given Massee's *British Fungus Flora.* A further grant up to £10 was sanctioned for the purpose of buying books.

Sunday, as usual, was left free for members to do as they pleased. Most went off in various groups and explored parts of Windsor Great Park, with the result that some extremely interesting species were found. On the fine old elms near the entrance two fungi which were new to most members were discovered, namely, *Polyporus spumeus* and *Pleurotus pantoleucus. Polyporus spumeus* grew from the wounds where large branches had been cut off, and when grasped in order to cut it away it was found to exude water exactly like a wet sponge. Other interesting species gathered in Windsor Park were *Collybia longipes* var. *badia, Omphalia velutina, Cortinarius dolabratus, Inocybe rhodiola,* and *Hebeloma longicaudum.*

In the evening Mr Brooks gave his paper on "Epidemic Plant Diseases*," an extremely useful summary of the nature, causes, and conditions of epidemic diseases.

Burnham Beeches, visited on Monday, proved a rich hunting-ground. Among the more rare and noteworthy species obtained were *Amanita porphyria, A. nitida, Pleurotus lignatilis, Cantharellus tubaeformis, Rozites caperatus, Inocybe pyriodora, Cortinarius triumphans, C. arvinaceus, C. argentatus, C. armillatus, C. saturninus, Hydnum coralloides,* and *H. erinaceus.*

In the evening the President, Professor O. V. Darbishire, delivered his Presidential Address on "Lichenology," a summary of the history and present position of the subject.

Two localities were included in the foray on the Tuesday, Brockhurst Wood and Stoke Common. The former in particular provided some additional records of interest, such as *Tricholoma cinerascens, Panus torulosus, Leptonia euchroa, Cortinarius claricolor, C. decoloratus, C. uliginosus, Stropharia caput-Medusae,* and *Diatrypella favacea* on birch.

In the evening Mr Carleton Rea gave an informal talk on the chief species found during the foray. A short communication

* See vol. IX, p. 228.

by the late Sir H. C. Hawley enumerated fourteen species of fungi found in August on a blackbird's nest*. Mr J. Ramsbottom gave a short paper on "Mushrooms and Toadstools" which had been broadcasted a few days previously.

Wednesday proved to be most uncompromisingly wet, but in spite of the fact that the rain started in the morning a charabanc load of brave spirits set out for Black Park, Langley, hoping that the weather would clear later. The hope proved unfounded, however, and search had soon to be given up. What little was done yielded some species of interest, which showed that the locality might have proved a rich one.

At the start the members proceeded to get rid of sandwiches in the shelter of a wood-shed, and from there at once observed a fallen elm quite covered with very fine specimens of *Pleurotus sapidus*, a species which had also been found in Windsor Park and at Burnham Beeches. A search in the wood-yard revealed *Coprinus picaceus*, and on a sawdust heap near the lake *Pluteus cervinus* var. *Bullii* and *P. eximius* were discovered. Other interesting finds were *Leptonia incana*, *Psilocybe canobrunnea*, and a curiously distorted form of *Polyporus betulinus*, apparently parasitised by some other fungus, which, however, could not be recognised.

In the evening the few members left enjoyed a short account given by Mr Ramsbottom of an attempted but unpublished monograph on Discomycetes by Dr M. C. Cooke.

The meeting closed with the usual votes of thanks to landowners, and in particular a very hearty vote of thanks was given to Mr Buckley, who had arranged the various excursions and acted as leader.

For assistance in compiling the subjoined list the Secretary is indebted to all members present, and in particular to Mr Carleton Rea, Mr Ramsbottom, Mr Buddin, Mr Grinling and Dr Bayliss Elliott.

List of Species gathered during the Foray.

V = Virginia Water; *W* = Windsor Park; *B* = Burnham Beeches; *S* = Stoke Common; *T* = Brockhurst Wood; *P* = Black Park, Langley.

HYMENOMYCETES.

Amanita phalloides (Vaill.) Fr., *V.*, *B.*, *T.*, *S.*, porphyria (A. & S.) Fr., *B.*, *T.*, mappa (Batsch) Fr., *V.*, *T.*, *P.*, and var. alba (Gill.) Rea, *V.*, *T.*, *P.*, muscaria (Linn.) Fr., *V.*, *B.*, *T.*, *S.*, spissa Fr., *V.*, *T.*, rubescens (Pers.) Fr., *V.*, *B.*, *T.*, nitida Fr., *B.*

Amanitopsis vaginata (Bull.) Roze, *V.*, fulva (Schaeff.) W. G. Sm., *V.*, *B.*, *S.*

Lepiota procera (Scop.) Fr., *W.*, rhacodes (Vitt.) Fr., *V.*, *W.*, felina (Pers.) Fr., *P.*, amaianthina (Scop.) Fr., *V.*, *T.*

Armillaria mellea (Vahl) Fr., *W.*, *V.*, *B.*, *T.*, *P.*, mucida (Schrad.) Fr., *B.*, *W.*, *T.*

Tricholoma fulvum (DC.) Fr., *W.*, *T.*, rutilans (Schaeff.) Fr., *V.*, *T.*, terreum (Schaeff.) Fr., *B.*, *T.*, cuneifolium Fr., *B.*, carneum (Bull.) Fr., *W.*, per-

* See vol. IX, p. 239.

sonatum Fr., *W.*, *B.*, glaucocanum Bres., *W.*, cinerascens (Bull.) Quél., *T.*, porphyroleucum (Bull.) Fr., *W.*

Clitocybe nebularis (Batsch) Fr., *T.*, *P.*, clavipes (Pers.) Fr., *T.*, *P.*, *V.*, aurantiaca (Wulf.) Studer, *V.*, *B.*, *T.*, rivulosa (Pers.) Fr., *W.*, cerussata Fr., *W.*, infundibuliformis (Schaeff.) Fr., *W.*, *V.*, geotropa (Bull.) Fr., *V.*, *W.*, flaccida (Sow.) Fr., *W.*, *P.*, suaveolens (Schum.) Fr., *T.*, brumalis Fr., *B.*, metachroa (Fr.) Berk., *V.*, ditopus Fr., *S.*, fragrans (Sow.) Fr., *W.*

Laccaria laccata (Scop.) B. & Br., and var. amethystina (Vaill.) B. & Br., *W.*, *V.*, *B.*, *T.*, *P.*

Collybia radicata (Relh.) Berk., *B.*, *T.*, longipes (Bull.) Berk. var. badia Lucand, *W.*, platyphylla (Pers.) Fr., *W.*, *B.*, fusipes (Bull.) Berk., *W.*, *B.*, maculata (A. & S.) Fr., *W.*, *V.*, *T.*, *B.*, butyracea (Bull.) Fr., *V.*, *T.*, cirrhata (Schum.) Fr., *B.*, tuberosa (Bull.) Fr., *V.*, *T.*, acervata Fr., *V.*, inolens Fr., *V.*, atrata Fr., *V.*, ambusta Fr., *W.*

Mycena pura (Pers.) Fr., *V.*, Adonis (Bull.) Fr., *B.*, flavo-alba Fr., *W.*, rugosa Fr., *V.*, *W.*, *B.*, *P.*, galericulata (Scop.) Fr., *V.*, *B.*, polygramma (Bull.) Fr., *V.*, *B.*, inclinata Fr., *W.*, *B.*, *T.*, ammoniaca Fr., *V.*, *B.*, *W.*, *T.*, *P.*, vitilis Fr., *B.*, sanguinolenta (A. & S.) Fr., *V.*, galopus (Pers.) Fr., *V.*, *T.*, *B.*, and var. nigra Fl. Dan., *V.*, *T.*, epipterygia (Scop.) Fr., *B.*, *T.*, stylobates (Pers.) Fr., *W.*

Omphalia pyxidata (Bull.) Fr., *W.*, *V.*, umbellifera (Linn.) Fr. var. citrina Quél., *B.*, velutina Quél., *W.*, fibula (Bull.) Fr., *T.*

Pleurotus corticatus Fr., *V.*, *W.*, lignatilis Fr., *B.*, sapidus Schulz., *W.*, *B.*, *P.*, pantoleucus Fr., *W.*, ostreatus (Jacq.) Fr., *T.*, revolutus Kick., *T.*, acerosus Fr., *V.*

Hygrophorus eburneus (Bull.) Fr., *B.*, cossus (Sow.) Fr., *T.*, coccineus (Schaeff.) Fr., *V.*, miniatus Fr., *T.*, chlorophanus Fr., *V.*, psittacinus (Schaeff.) Fr., *V.*, unguinosus Fr., *V.*

Lactarius turpis (Weinm.) Fr., *V.*, *B.*, *S.*, pubescens Fr., *V.*, *T.*, insulsus Fr., *W.*, blennius Fr., *V.*, *W.*, *T.*, circellatus Fr., *B.*, chrysorheus Fr., *V.*, *B.*, *T.*, *P.*, vellereus Fr., *W.*, *B.*, quietus Fr., *B.*, *T.*, *V.*, aurantiacus (Fl. Dan.) Fr., *B.*, theiogalus (Fr.) Plowr., *V.*, *T.*, *P.*, vietus Fr., *B.*, rufus (Scop.) Fr., *T.*, *P.*, glyciosmus Fr., *W.*, *B.*, serifluus (DC.) Fr., *B.*, *T.*, *P.*, subdulcis (Pers.) Fr., *V.*, *B.*, *T.*, *P.*, cimicarius (Batsch) Cooke, *V.*

Russula chloroides (Krombh.) Bres., *W.*, nigricans (Bull.) Fr., *V.*, *W.*, *T.*, adusta (Pers.) Fr., *T.*, incarnata Quél., *T.*, lepida Fr., *V.*, *W.*, azurea Bres., *V.*, cyanoxantha (Schaeff.) Fr., *V.*, *B.*, *S.*, furcata (Pers.) Fr., *V.*, *B.*, *S.*, *T.*, pectinata (Bull.) Fr., *W.*, ochroleuca (Pers.) Fr., *V.*, *W.*, *B.*, *T.*, *P.*, fellea Fr., *V.*, *B.*, *T.*, fragilis (Pers.) Fr., *W.*, *V.*, *B.*, *T.*, and var. fallax (Schaeff.) Mass., *W.*, *V.*, emetica (Schaeff.) Fr., *W.*, *V.*, *B.*, *T.*, *P.*, atropurpurea (Krombh.) Maire, *W.*, *B.*, *T.*, integra (Linn.) Bat., *W.*, xerampelina (Schaeff.) Fr., *V.*, vesca Fr., *W.*, *V.*, punctata (Gill.) Maire, *W.*, mustelina Fr., *W.*, *T.*, lutea (Huds.) Fr., *V.*, and var. armeniaca (Cooke) Rea, *W.*, *B.*, *T.*

Cantharellus cibarius Fr., *W.*, *V.*, *T.*, *P.*, carbonarius (A. & S.) Fr., *S.*, tubaeformis Fr., *B.*, *T.*, infundibuliformis (Scop.) Fr., *T.*

Marasmius peronatus (Bolt.) Fr., *W.*, *V.*, *T.*, oreades (Bolt.) Fr., *W.*, erythropus (Pers.) Fr., *W.*, *P.*, hariolorum (DC.) Quél., *V.*, dryophilus (Bull.) Karst., *W.*, *S.*, and var. aquosus (Bull.) Rea, *V.*, ramealis (Bull.) Fr., *T.*

Androsaceus androsaceus (Linn.) Pat., *V.*, *T.*

Panus torulosus (Pers.) Fr., *T.*, stypticus (Bull.) Fr., *T.*

Lenzites betulina (Linn.) Fr., *T.*, saepiaria (Wulf.) Fr., *V.*

Pluteus cervinus (Schaeff.) Fr., *W.*, *V.*, *T.*, *P.*, and var. Bullii Berk., *P.*, eximius Saund. & Sm., *P.*, umbrosus (Pers.) Fr., *V.*

Entoloma rhodopolium Fr., *W.*, *T.*, sericeum (Bull.) Fr., *W.*, *V.*, *T.*, nidorosum Fr., *B.*, *S.*

Nolanea pascua (Pers.) Fr., *W.*, *V.*, *T.*

Leptonia euchroa (Pers.) Fr., *T.*, incana Fr., *P.*, sericella (Fr.) Quél., *W.*

Eccilia rhodocylix (Lasch) Fr., *W.*

Pholiota togularis (Bull.) Fr., *W.*, dura (Bolt.) Fr., *T.*, radicosa (Bull.) Fr., *B.*, squarrosa (Müll.) Fr., *W.*, spectabilis Fr., *V.*, *P.*, mutabilis (Schaeff.) Fr., *T.*, marginata (Batsch) Fr., *T.*

Rozites caperatus (Pers.) Karst., *B.*
Inocybe pyriodora (Pers.) Fr., *W.*, *B.*, rimosa (Bull.) Fr., *W.*, geophylla (Sow.) Fr., *W.*, *V.*, cervicolor (Pers.) Quél., *V.*, cincinnata Fr., *T.*, rhodiola Bres., *W.*, fastigiata (Schaeff.) Fr., *W.*, *V.*
Astrosporina proximella (Karst.) Rea, *W.*, *V.*, asterospora (Quél.) Rea, *V.*, sabuletorum (B. & C.) Rea, *V.*, *S.*, petiginosa (Fr.) Rea, *T.*
Hebeloma fastibile Fr., *V.*, *W.*, *S.*, glutinosum (Lindgr.) Fr., *W.*, mesophaeum Fr., *W.*, crustuliniforme (Bull.) Fr., *T.*, and var. minus Cke, *W.*, *B.*, longicaudum (Pers.) Fr., *W.*
Flammula lubrica (Pers.) Fr., *V.*, gummosa (Lasch) Fr., *W.*, carbonaria Fr., *V.*, *T.*, *P.*, flavida (Schaeff.) Fr., *B.*, sapinea Fr., *V.*, *T.*, *P.*, ochrochlora Fr., *P.*
Naucoria melinoides Fr., *B.*, conspersa (Pers.) Fr., *B.*, *T.*, escharoides Fr., *V.*
Galera tenera (Schaeff.) Fr., *W.*, hypnorum (Schrank) Fr., *V.*, *T.*, *S.*
Tubaria furfuracea (Pers.) W. G. Sm., *W.*, paludosa Fr., *V.*, *T.*, inquilina (Fr.) W. G. Sm., *W.*, *T.*
Crepidotus alveolus (Lasch) Fr., *W.*
Cortinarius (Phlegmacium) triumphans Fr., *B.*, claricolor Fr., *V.*, *T.*, decoloratus Fr., *W.*, *T.*
— (Myxacium) arvinaceus Fr., *B.*, collinitus (Sow.) Fr., *W.*, *T.*, mucosus (Bull.) Fr., *T.*, elatior Fr., *V.*, *B.*, *T.*
— (Inoloma) argentatus (Pers.) Fr., *B.*, pholideus Fr., *V.*
— (Dermocybe) caninus Fr., *V.*, *T.*, anomalus Fr., *V.*, semisanguineus (Brig.) Maire, *W.*, *B.*, sanguineus (Wulf.) Fr., *B.*, cinnamomeus (Linn.) Fr., *B.*, uliginosus Berk., *T.*
— (Telamonia) torvus Fr., *V.*, *T.*, armillatus Fr., *B.*, hinnuleus (Sow.) Fr., *B.*, *T.*, brunneus (Pers.) Fr., *P.*, incisus (Pers.) Fr., *W.*, *B.*, hemitrichus Fr., *V.*, *B.*, *T.*, rigidus (Scop.) Fr., *V.*, *T.*
— (Hydrocybe) saturninus Fr., *B.*, castaneus (Bull.) Fr., *B.*, *P.*, dolabratus Fr., *W.*, leucopus (Bull.) Fr., *T.*, decipiens (Pers.) Fr., *V.*, acutus (Pers.) Fr., *B.*
Paxillus involutus (Batsch) Fr., *W.*, *V.*, *B.*, *T.*, atro-tomentosus (Batsch) Fr., *V.*
Psaliota Elvensis B. & Br., *W.*, campestris (Linn.) Fr., *W.*, *V.*
Stropharia aeruginosa (Curt.) Fr., *W.*, *V.*, *T.*, squamosa (Pers.) Fr., *V.*, *B.*, *T.*, semiglobata (Batsch) Fr., *V.*, *W.*, *B.*, *T.*, caput-Medusae Fr., *T.*
Hypholoma sublateritium (Schaeff.) Fr., *V.*, epixanthum Fr., *W.*, fasciculare (Huds.) Fr., *V.*, *T.*, lacrymabundum Fr., *T.*, appendiculatum (Bull.) Fr., *B.*, *T.*, *P.*, leucotephrum B. & Br., *B.*, hydrophilum (Bull.) Fr., *W.*, *B.*, *P.*
Psilocybe ericaea (Pers.) Fr., *B.*, uda (Pers.) Fr., *V.*, *S.*, bullacea (Bull.) Fr., *V.*, *T.*, semilanceata Fr., *V.*, *T.*, canobrunnea (Batsch) Fr., *P.*, spadicea Fr., *T.*
Psathyra pennata Fr., *V.*, *B.*, *T.*, *S.*
Bolbitius titubans (Bull.) Fr., *T.*
Coprinus comatus (Fl. Dan.) Fr., *W.*, atramentarius (Bull.) Fr., *W.*, picaceus (Bull.) Fr., *P.*, cinereus (Schaeff.) Cke, *W.*, *V.*, *T.*, niveus (Pers.) Fr., *W.*, micaceus (Bull.) Fr., *W.*, *P.*, domesticus (Pers.) Fr., *S.*, plicatilis (Curt.) Fr., *V.*, *T.*
Panaeolus sphinctrinus Fr., *W.*, *T.*, campanulatus (Linn.) Fr., *V.*, *T.*, *B.*
Psathyrella gracilis Fr., *T.*, atomata Fr., *W.*, *S.*, disseminata (Pers.) Fr., *V.*, *B.*
Gomphidius glutinosus (Schaeff.) Fr., *V.*, viscidus (Linn.) Fr., *T.*
Boletus elegans (Schum.) Fr., *T.*, badius Fr., *V.*, *B.*, *T.*, bovinus (Linn.) Fr., *B.*, variegatus (Swartz) Fr., *T.*, chrysenteron (Bull.) Fr., *V.*, *B.*, *T.*, *P.*, subtomentosus (Linn.) Fr., *V.*, *T.*, pruinatus Fr., *V.*, *P.*, pinicola (Vitt.) Rea, *V.*, reticulatus (Schaeff.) Boud., *V.*, *T.*, aestivalis (Paul.) Fr., *W.*, luridus (Schaeff.) Fr., *V.*, *T.*, versipellis Fr., *V.*, *B.*, *T.*, scaber (Bull.) Fr., *V.*, *B.*, *T.*, *S.*
Fistulina hepatica (Huds.) Fr., *W.*, *T.*
Polyporus perennis (Linn.) Fr., *W.*, *S.*, squamosus (Huds.) Fr., *W.*, *V.*, *P.*, intybaceus Fr., *B.*, *P.*, Schweinitzii Fr., *V.*, *T.*, *P.*, giganteus (Pers.) Fr., *W.*, betulinus (Bull.) Fr., *P.*, dryadeus (Pers.) Fr., *W.*, adiposus B. & Br., *V.*, *B.*, adustus (Willd.) Fr., *V.*, *T.*, caesius (Schrad.) Fr., *T.*, spumeus (Sow.) Fr., *W.* (on *elm*).

Fomes ulmarius (Sow.) Fr., *W.*, annosus Fr., *V.*
Ganoderma applanatum (Pers.) Pat., *W.*, and var. laccatum (Kalchbr.) Rea, *W.*
Polystictus versicolor (Linn.) Fr., *T.*
Poria mollusca (Pers.) Fr., *V.*
Trametes gibbosa (Pers.) Fr., *V.*, *T.*, rubescens (A. & S.) Fr., *B.*, *T.*
Daedalea biennis (Bull.) Quél., *W.*, quercina (Linn.) Fr., *B.*
Merulius tremellosus (Schrad.) Fr., *W.*, *V.*, *B.*
Phlebia merismoides Fr., *W.*, *B.*, *T.*
Hydnum repandum (Linn.) Fr., *B.*, *T.*, coralloides (Scop.) Fr., *B.*, erinaceus (Bull.) Fr., *B.*
Acia uda (Fr.) Bourd. & Galz., *T.*
Irpex obliquus (Schrad.) Fr., *V.*
Odontia farinacea (Pers.) Quél., *V.*
Craterellus cornucopioides (Linn.) Fr., *T.*
Thelephora terrestris (Ehrb.) Fr., *V.*, *B.*
Hypochnus fuscus (Pers.) Fr., *V.*, *T.*, fumosus Fr., *V.*
Stereum multizonatum (B. & Br.) Mass., *W.*, rugosum (Pers.) Fr., *V.*, hirsutum (Willd.) Fr., *T.*, *S.*, purpureum (Pers.) Fr., *W.*, *B.*
Sparassis crispa (Wulf.) Fr., *V.*, *B.*, *P.*
Hymenochaete rubiginosa (Dicks.) Lév., *B.*, *T.*
Corticium laeve (Pers.) Fr., *B.*, *T.*, arachnoideum Berk., *V.*, subcoronatum v. H. & Litsch., *V.*
Peniophora Aegerita v. H. & Litsch., *T.*, cremea Bres., *V.*, setigera (Fr.) Bres., *V.*, *B.*, aurantiaca (Bres.) B. & G., *B.*, cinerea (Fr.) Cke, *V.*, quercina (Pers.) Cke., *V.*
Coniophora puteana (Schum.) Karst., *V.*, *W.*, arida Fr., *P.*
Solenia anomala (Pers.) Fr., *B.*
Clavaria cristata (Holmsk.) Fr., *V.*, *B.*, cinerea (Bull.) Fr., *V.*, rugosa (Bull.) Fr., *B.*, stricta (Pers.) Fr., *S.*, *T.*, inaequalis (Müll.) Fr., *V.*
Typhula erythropus (Bolt.) Fr., *B.*
Pistillaria quisquiliaris Fr., *B.*
Auricularia mesenterica (Dicks.) Fr., *P.*, auricula-Judae (Linn.) Schroet., *V.*
Tremella mesenterica (Retz.) Fr., *V.*
Tremellodon gelatinosum (Scop.) Pers., *V.*, *T.*
Dacryomyces deliquescens (Bull.) Duby, *V.*
Calocera viscosa (Pers.) Fr., *V.*, *B.*, stricta Fr., *T.*, *P.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *W.*, *V.*, *T.*
Mutinus caninus (Huds.) Fr., *B.*, *P.*
Sphaerobolus stellatus (Tode) Pers., *V.*, *B.*, *T.*
Crucibulum vulgare Tul., *V.*
Lycoperdon depressum Bon., *V.*, umbrinum Pers., *V.*, *B.*, perlatum Pers., *V.*, *B.*, *T.*, *P.*, pyriforme (Schaeff.) Pers., *W.*, *T.*
Scleroderma vulgare Hornem., *W.*, *V.*, *S.*

UREDINEAE.

Uromyces Valerianae (Schum.) Fckl., *B.*
Puccinia Violae (Schum.) DC., *V.*, Menthae Pers., *V.*, obscura Schroet., *T.*, Caricis (Schum.) Rebent., *V.*
Phragmidium Fragariae (DC.) Wint., *V.* on *Potentilla erecta*, *V.*, subcorticium (Schrank) Wint., *V.*, Rubi (Pers.) Wint., *V.*
Pucciniastrum Epilobii (Pers.) Otth., *V.*, *B.*, *T.*
Melampsoridium betulinum (Pers.) Kleb., *V.*, *B.*, *T.*

USTILAGINEAE.

Ustilago longissima (Sow.) Tul., *V.*
Sphacelotheca Hydropiperis (Schum.) de By., *W.*

DISCOMYCETES.

Aleuria Emileia (Cooke) Boud., *V.*
Otidea onotica (Pers.) Fuck., *T.*

Peziza aurantia Pers., *B.*, rutilans Fr., *B.*
Leotia lubrica (Scop.) Pers., *W.*
Cudoniella acicularis (Bull.) Schroet., *B.*, *T.*
Bulgaria inquinans (Pers.) Fr., *T.*
Calycella lenticularis (Bull.) Boud., *V.*, sublenticularis (Fr.) Boud., *B.*, ferruginea (Schum.) Boud., *B.*
Orbilia xanthostigma Fr., *V.*, *B.*
Sclerotinia Curreyana (Berk.) Karst., *B.*
Stromatinia pseudotuberosa (Rehm) Boud., *V.*
Phialea firma (Pers.) Gill., *B.*
Helotium herbarum (Pers.) Fr., *B.*
Dasyscypha virginea (Batsch) Fuck., *B.*, luteola (Curr.) Sacc., *S.*, ciliaris (Schrad.) Sacc., *B.*, fuscescens (Pers.) Rehm, *B.*
Trichoscypha calycina (Schum.) Boud., *V.*
Mollisia cinerea (Batsch) Karst., *V.*, *B.*
Tapesia fusca (Pers.) Fuck., *V.*
Stegia Ilicis Fr., *T.*
Rhytisma acerinum (Pers.) Fr., *V.*

PYRENOMYCETES.

Uncinula Aceris (DC.) Sacc., *V.*
Erysiphe Polygoni DC. (on *clover*), *W.*
Nectria cinnabarina (Tode) Fr., *V.*, *T.*
Hypomyces rosellus Tul., *P.*
Cordyceps militaris (Linn.) Link, *V.*
Claviceps microcephala (Wallr.) Wint., on *Molinia*, *Dactylis* and *Lolium*, *W.*, *B.*, *T.*
Leptospora ovina (Pers.) Fuck., *B.*
Melanomma pulvis-pyrius (Pers.) Fuck., *B.*
Leptosphaeria Doliolum (Pers.) Ces. & de Not., *B.*
Melanconis stilbostoma (Fr.) Tul., *B.*
Diatrype disciformis (Hoffm.) Fr., *V.*
Diatrypella favacea (Fr.) de Not., *T.*
Hypoxylon coccineum Bull., *T.*
Xylaria Hypoxylon (Linn.) Grev., *W.*, *V.*, *T.*
Dothidella Ulmi (Duv.) Wint., *V.*
Dichaena quercina Fr., *B.*
Rhopographus Pteridis (Sow.) Wint., *B.*

PHYCOMYCETES.

Spinellus fusiger (Link) van Tiegh., *V.*
Syzygites megalocarpus Ehrb., *V.*

SPHAEROPSIDEAE.

Septoria Rubi West., *V.*, *B.*
Libertella faginea Desm., *B.*

HYPHOMYCETES.

Cylindrium aeruginosum (Link) Lindau, *B.*
Oidium alphitoides Griff. & Maubl., *V.*, *B.*, *T.*, *S.*
Ovularia obliqua (Cooke) Oud., *B.*, *T.*
Botrytis Tilletii Desm., *V.*
Ramularia calcea (Desm.) Ces., *V.*, Knautiae (Mass.) Bub., *T.*, Lampsanae (Desm.) Sacc., *B.*
Rhinotrichum repens Preuss, *V.*, Thwaitesii B. & Br., *T.*
Sepedonium chrysospermum (Bull.) Fr., *T.*
Menispora ciliata Corda, *B.*
Bispora monilioides Corda, *T.*
Isaria farinosa Fr., *B.*

MYCETOZOA OF THE WINDSOR FORAY.

By G. Lister, F.L.S.

On September 29th the party visited Virginia Water, where the timber consists of Beech, Spanish Chestnut, Oak, Scotch Fir, Spruce and Holly, with some undergrowth of Rhododendron. Fine old stumps of Silver Fir and Spruce yielded large quantities of *Tubifera ferruginosa*, young and old; in the hollow of a large stump was abundance of *Hemitrichia Vesparium*, associated with *Trichia floriformis*, a species not common in Britain. On October 1st the party drove to near Burnham Beeches, visiting first a moor from which timber had been cleared. Here wide stretches of the moss *Campylopus pyriformis* were searched in vain for *Colloderma oculatum*, an inconspicuous species often found in such a habitat; cushions of the moss were, however, brought away and kept moist, and on them sporangia of *Colloderma* first appeared on October 23rd, and continued to emerge to the number of forty until December 8th, when the moss became disturbed by burrowing grubs. On October 2nd Brockhurst Woods and Stoke Common were searched. A small plantation of Scotch Fir yielded, among other species, *Comatricha fimbriata*, a minute form not recorded before for Buckinghamshire. Heaps of faggots and sticks proved the rich hunting ground; here amongst other kinds were found the plasmodium of *Badhamia utricularis* which afterwards developed into sporangia, and many small aethalia of *Enteridium olivaceum*. The total number of Mycetozoa found during the foray was thirty-seven.

Ceratiomyxa fruticulosa (Mueller) Macbr., *V.*
Badhamia utricularis (Bull.) Berk., *S.*, *T.*
Physarum nutans Pers., *V.*, *B.*, *S.*, *T.*
P. viride (Bull.) Pers., *V.*, *B.*, *S.*, *T.*
P. compressum Alb. & Schw., *S.*, *T.*
Fuligo septica (L.) Gmel., *V.*, *B.*, *S.*, *T.*
F. muscorum Alb. & Schw., *V.*
Craterium minutum (Leers) Fries, *V.*
C. leucocephalum Ditm., *V.*
Diderma spumarioides Fries, *V.*
Didymium difforme (Pers.) Duby., *S.*, *T.*
D. squamulosum (Alb. & Schw.) Fries, *B.*, *S.*, *T.*
D. Clavus (Alb. & Schw.) Rab., *S.*, *T.*
Colloderma oculatum (Lipp.) G. Lister, *B.*
Stemonitis fusca Roth., *V.*, *B.*, and var. confluens Lister, *V.*
S. hyperopta Meyl. (syn. Comatricha typhoides var. heterospora Rex), *V.*
Comatricha nigra (Pers.) Schroet., *V.*, *B.*
C. fimbriata G. Lister & Cran., *S.*, *T.*
C. typhoides (Bull.) Rost., *V.*
Cribraria argillacea Pers., *V.*
C. vulgaris Schrad., *V.*, *B.*, *S.*, *T.*
Licea flexuosa Pers., *V.*, *B.*
Tubifera ferruginosa Gmel., *V.*, *B.*
Reticularia Lycoperdon Bull., *V.*, *B.*
Enteridium olivaceum Ehrenb., *S.*, *T.*
Lycogala epidendrum (L.) Fr., *S.*, *T.*
Trichia persimilis Karst., *V.*
T. scabra Rost., *V.*
T. varia Pers., *V.*, *B.*, *S.*, *T.*

T. Botrytis Pers. var. flavicoma Lister, *S.*, *T.*
T. floriformis (Schwein.) G. Lister, *V.*
Hemitrichia Vesparium (Batsch) Macbr., *V.*
Arcyria cinerea (Bull.) Pers., *S.*, *T.*
A. pomiformis (Leers) Rost., *V.*, *B.*
A. denudata (L.) Wettst., *V.*, *B.*, *S.*, *T.*
A. incarnata Pers., *B.*, *S.*, *T.*
A. nutans (Bull.) Grev., *V.*, *B.*

LICHENS OF THE WINDSOR FORAY.

By H. H. Knight, M.A.

CORTICOLOUS Lichens were not plentiful in this district, and common species like *Parmelia* and *Evernia prunastri* were often poorly developed. Saxicolous Lichens were found mostly on stone or brick walls, but three species of Lecanora, *L. parella*, *L. atra* and *L. sulphurea* were growing on sandstone rocks at Virginia Water. The sandy soil was suitable for some of the terricolous Lichens, as species of *Cladonia*, and *Lecidea granulosa* and *uliginosa*. In the case of some of the common species no locality is given.

Chaenotheca melanophaea Zwackh., *B.*
Cyphelium inquinans Trev., *W.*
Peltigera canina Willd., *V.*
P. polydactyla Hoffm., *V.*
Parmelia physodes Ach.
P. caperata Ach., *B.*
P. saxatilis Ach., *W.*
P. sulcata Tayl.
P. dubia Tayl., *W.*
P. fuliginosa Nyl. var. laetevirens Nyl., *B.*
Evernia prunastri Ach., *B.*
Xanthoria parietina Th. Fr.
X. lychnea Th. Fr., *W.*
Placodium murorum DC., *W.*
P. luteo-album Hepp., *W.*
Candelariella vitellina Müll.-Arg., *W.*
Physcia pulverulenta Nyl., *W.*
P. hispida Tuckerm., *W.*
P. caesia Nyl., *W.*
P. orbicularis Dal. Tor. & Sarnth. var. virella Dal. Tor. & Sarnth., *W.*
Rinodina demissa Arn., *V.*
Lecanora muralis Schaer. on bridge at Eton.
L. subfusca Ach., *B.*
L. rugosa Ach., *V.*
L. campestris B. de Lesd., *W.*
L. atra Ach., *V.*
L. Hageni Ach., *W.*
L. galactina Ach., *W.*
L. varia Ach.
L. sulphurea Ach., *V.*
L. parella Ach., *V.*
Lecania erysibe Mudd, *V.*, *W.*
Pertusaria fagînea Leight.
P. pertusa Dal. Tor. & Sarnth.
Baeomyces rufus DC., *B.*
Cladonia sylvatica Hoffm., *T.*
C. pyxidata Hoffm., *B.*
C. fimbriata Fr.
C. furcata Schrad., *B.*
C. digitata Hoffm., *B.*
C. macilenta Hoffm., *B.*
C. Floerkeana Fr., *B.*
Lecidea ostreata Schaer., *W.*
L. quernea Ach., *V.*
L. granulosa Schaer., *V.*, *B.*
L. uliginosa Ach., *V.*, *B.*
L. fuliginea Ach., *V.*
Biatorina Griffithii Massal., *V.*
Buellia canescens De Not.
B. myriocarpa Mudd
Opegrapha varia Pers., *W.*
Graphis elegans Ach., *B.*, *T.*
Enterographa crassa Fée, *V.*

PRESIDENTIAL ADDRESS.

(With 1 Text-fig.)

By Prof. O. V. Darbishire.

SOME ASPECTS OF LICHENOLOGY.

About one hundred years ago on January 2nd, 1822, there was born, at Uleaborg in Finland, William Nylander (11) who was to become a great lichen-systematist. He qualified as a doctor, and in 1847 wrote his first paper on lichens. From 1857 to 1863 he acted as professor of Botany at Helsingfors, paying during that time, however, frequent botanical visits to Paris. He ultimately settled down there to devote his whole time and energy to the detailed study of lichens, and died in March 1899. He was in many respects a typical representative of the lichenologists of the nineteenth century, and for many years was to many lichenologists the last court of appeal in the case of doubtful species. Although he published his first paper in 1847, his last contribution to lichenology was not made till 1898, after a period of fifty-one years of ceaseless hard work. He had in Paris wonderful opportunities for working through lichen-material brought together from all parts of the world, and he made full use of these opportunities, thereby acquiring a deep knowledge of lichen-species and lichen-genera. At first strongly opposed to the "splitting" of species, he later became just the reverse, perhaps a not uncommon occurrence with many systematists. He evolved a system of classification (12, p. 11) which may have some adherents even now. At one end of his system the Ephebacei and Collemacei passed into the algae and at the other the Pyrenocarpei were connected with the fungi. This artificial system has long been replaced by a more natural one. Nothing in fact remains of Nylander's work but a host of species and genera of which he is the author, and many of his species are a sore trial to lichenologists of to-day. A large number are no longer decipherable, though there is no doubt that he knew his species well and they were generally good species. But he named new species with a total disregard for the equally good work of those of his contemporaries who did not follow him absolutely. There can unfortunately be no doubt that on this account many species of the last century have at least two names apart from the usual synonyms. At the same time, Nylander's services to lichenology were very great. He very fully appreciated the value of generic differences, though to many genera of to-day he gave only the rank of sub-genera. His descriptions, however, were generally very brief and only very rarely accompanied by figures.

Seven years after the birth of Nylander, on February 10th, 1829, there was born in Switzerland, Simon Schwendener (6), who died as late as May 1919, at the advanced age of 90. Schwendener became Assistant to Naegeli at Munich in 1857 and held a University post for the rest of his life. To him was due the formulation in 1867 of the theory of the dual nature of lichens (23). He came to this result in the course of a careful study and comparative survey of the structure of lichens, begun in 1860 and completed in 1868 (22). His theory immediately met with much opposition, which has not even yet completely died down. The refusal to accept Schwendener's theory at first came mainly from lichen-systematists and was due to the fear that with its acceptance the autonomous group of lichens would disappear and the various genera would be relegated to places amongst the algae or fungi. Opposition was not originally based on any experimental evidence or extensive microscopical research. Latterly, however, Elfving (10) has again attempted to show that gonidial cells, which we generally now consider to be algae, are derived really from the colourless hyphae which we regard as fungi. Elfving's work has been carried out with great care and should receive equally careful consideration.

I like to compare and contrast these two men—Nylander and Schwendener. The former a systematist, pure and simple, rather narrow-minded, and towards the end of his life very soured and almost a recluse in his home life and in his work. He wrote very bitterly against Schwendener, whose theory he absolutely refused to accept. His work is unknown to the ordinary botanist. On the other hand, we have Schwendener who—one might almost say—merely dabbled in lichenology, yet completely changed our ideas as to the nature of lichens and thus rendered a great service to Botany generally. All subsequent physiological and systematic work on lichens is based on Schwendener's theory of the dual nature of the lichen thallus. Schwendener really did little more than examine anatomically a large number of lichens, and the clear insight he thus obtained turned his thoughts to a special study of the colourless hyphae in their relation to the green gonidia, whose likeness to free algae struck him. He found an explanation for this similarity in the discovery that they were algae imprisoned by a fungus. Having settled this matter, he left the lichens and went on to the higher plants. Lichens differ so much from algae and fungi that, in spite of Schwendener's theory, there can be no question of relegating the lichens to their nearest relatives among the algae and fungi.

Nylander and Schwendener held two totally different points of view, and there was at first no co-operation between the two groups of workers of which they may be said to be representative. We will see later how far this is still the case.

Systematic lichenology has at the present moment reached such a state that it can only be saved by the monographing of families, genera and even species. This will probably have to be accompanied by the wholesale dropping of many old names. In order to be sure of our species and their distribution it will be necessary to bring together and examine critically typical representatives of one species from all over the world in order to correlate the interpretations by various authors of such a species. Dr A. Zahlbruckner of Vienna has been publishing since 1922 a Catalogus Lichenum Universalis (31) of which Volume I has appeared and the second volume is nearing completion. It will contain a complete list of lichen-species and their synonymy and references to literature, but it is not a critical revision of the species or genera. It does not contain descriptions of species but is merely a guide to the best descriptions and the most important Exsiccata. It should form an invaluable aid to any monographer, and I hope will encourage those who have the necessary opportunity and patience to embark on a monograph of some genus or species. If carried through carefully the worker would be well rewarded, as he would find such an undertaking full of interest. Let us take only one well-known species, *Lecanora subfusca* (L.) Ach. Do all the specimens referred to by this name belong to the same species, whether collected in America, Africa, the Arctic or Antarctic continent, Europe or Asia and so on, disregarding for the moment the vexed question as to what a species really is? *Lecanora subfusca* also changes its appearance and structure completely according as to whether it grows on wood or stone, and includes endless varieties and "sub-species." Such a monograph would be of the greatest interest too from a phyto-geographical point of view, and it is not unlikely that it might also help to explain some difficulties encountered in the distribution of the higher plants. Many Arctic species of lichens are recorded for the Antarctic continent. On the other hand, in the Roccellei the species found in America are not met with in the Old World. A monograph of this family (8) was necessary before this was made clear.

It is often very difficult to define and separate lichen-species. In the higher plants we have the morphological differentiation of the shoot into stem and leaf, in addition to the separation of a root, and with these there is associated a definite differentiation of tissue and form. All these are often characteristic for whole natural orders or other groupings. In addition to these vegetative features we have the characters of the reproductive organs represented by the essential and accessory organs of the flowers. Natural orders are, as a rule, clearly separated by these. It is true that in the special form of adaptation—whatever the

origin of the latter—many of these common morphological features have become modified, and thus further differences or divergencies may occur. But on the whole, natural orders of flowering plants are characterised and may be separated by the structure of the reproductive organs and by certain definite vegetative features which can be detected even in certain adaptations, which tend to wipe out differences. A very different state of affairs obtains in lichens. Differentiation in the lichen thallus is almost quite free from ancestral morphological tradition which has such a profound influence on the present-day flowering plant. The lichen-fungus has shaken off the habits and the morphological and structural differentiation of its saprophytic or parasitic ancestors and has built up new and mainly physiological traditions. To such an extent has the lichen-fungus broken with its pure fungus traditions that it is no longer generally able to grow as a free fungus on the germination of its ascospore; it is already so dependent on the algae that it cannot grow into a mature plant in their absence. The lichen-fungus again is in such close and intimate touch with the surrounding conditions that its very life depends on an immediate ontogenetic response of the whole lichen-organism to any slight variation in external conditions and the result is a remarkable convergence in type of species not necessarily closely related but growing under similar conditions. Undoubted polyphyletic development has occurred of the whole group of lichens and also of genera and possibly even of species. Some species of Cladonia will doubtless be found to show such development. It was this marked convergence which misled Nylander to construct portions of his system in such a way that the series of the Cladodei included all the fruticulose lichen-genera, and the Parmeliodei and Phyllodei all the foliaceous lichen-genera (12). These series have now been broken up and the genera have been assigned different and more natural places. The classification of to-day—due mainly to Reinke and Zahlbruckner (31)—depends for its main divisions chiefly on the nature of the fungal apothecium and its spores, whereas in natural orders, genera and species pure lichen characters play an increasingly important part. To a limited extent the algae have a determining voice in the separation of certain groups and genera. The limiting of species, already not easy owing to the convergence of types, may possibly be further rendered more difficult by the occurrence of ordinary hybrids. We may get to know more about the possibilities in this direction when we know more about the sexual process which is still only presumed to occur on nevertheless very strong circumstantial evidence. Experimental work may then become possible. Further diffi-

culties might occur owing to the formation of graft hybrids. Tobler describes the building up of a Cetraria thallus by the fusion of numerous small germling Cetraria thalli (29). The same process has been recorded for a crustaceous lichen (1, p. 56). Bitter suggests the possibility of the occurrence of hybrids between *Parmelia tubulosa* (Schaerer) Bitter and *P. physodes* (L.) Ach. although he could not find any actual evidence in favour of this suggestion. He refers to Hue and Nylander, who were inclined to see in certain forms intermediate between *Ramalina fastigiata* and *R. fraxinea* possible hybrids (2, p. 271). A hybrid might be produced in this way conceivably differing "specifically" from either of its parents.

These few remarks indicate some of the difficulties with which the lichen-systematist has to contend when endeavouring to define species.

Incidentally, no one in this country should find any special difficulty in naming British specimens. Miss Lorrain Smith's two big volumes (24) and one small handbook (26) should ensure that. We are to be congratulated on having the lichen literature in this country so up-to-date. Miss Lorrain Smith's textbook on lichens (25) makes our English contemporary lichen literature as complete as can be desired. But these books are only guides —very good ones, it is true—and the chief work has still to be done when the collector brings in his first specimens. Microscopical work is necessary and untold patience and care. Once beyond the initial, difficult and apparently hopeless stage a new world of the greatest interest lies open before the student. Dr Watson's small guide is also a most useful help in the field (30). I wish more of our members could be persuaded to take up the study of lichens.

Lichen ecology is a subject of the greatest interest and importance to the botanist in general and the ecologist in particular. Lichens are so profoundly influenced by their substratum that they immediately reflect its nature and structure probably more than any other group of plants. The lichen growing quite on the outskirts of vegetation initiates the breaking down of rocks and thus aids in the making of soil. The lichen is almost everywhere the pioneer of the whole plant world. It is, with few exceptions, the only plant which is both directly and indirectly independent of an organic substratum and of water stored outside in the substratum or near by. The lichen can therefore grow where practically nothing else will. Arctic and antarctic, alpine and mountainous regions, generally have their rocks covered with lichens as long as they are not permanently covered with snow. Rocks along the sea-coast, and the driest portions of a tree are often covered with lichens. These are found also in the

driest parts of the desert, and are epiphyllous on leaves of trees in the tropical forests.

A very large amount of work has been done since Schwendener's time on the structure of lichens, but it is, on the whole, disconnected and hence our general knowledge of their anatomy has advanced but little. Nobody has worked harder at the structure of lichens than the learned Abbé Hue who died a few years ago. He published two large tomes (13, 14) between 1901 and 1910, and numerous smaller papers containing contributions to our knowledge of the subject. Much of his work consists, however, of rather uninteresting records of minute measurements of cell-sizes, cell-forms, depth of whole thalli and of separate tissues and layers and so on. Little or no regard is paid to the state of development of the lichen as a whole or that of the tissue or the special function of the latter, or to the more important surrounding ecological and physiological conditions which might influence structure. In one such paper (14, no. 589-691) over a hundred crustaceous species of one genus—Aspicilia—are described down to the most minute detail as regards the structure of the thallus. Very little is gained by this, very often not even an easier and surer way of separating two difficult species. As a result of his long experience, however, Hue has proposed a classification of the tissues of lichens, which is to some extent satisfactory, but it is not based on the function of the tissues. Miss Smith gives a full account of this scheme (25, p. 69).

A great deal of anatomical work still remains to be done. It should be realised again that physiological differentiation of the tissues is more marked than traditional morphological differentiation. The lichen is of such great general interest because—as I mentioned before—it has dropped all the traditions, prejudices and memories of its fungal ancestors. No other group of land-plants is as a whole so up-to-date in its structural adaptations. The lichen has no unnecessary vegetative organs or vestiges of such. It must be well adapted, as otherwise under the adverse surrounding conditions it would perish. To appreciate this properly the field lichenologist and the physiologist (and ecologist) must co-operate. There should be no such contrast as existed during the last quarter of the nineteenth century between the followers of Nylander and Schwendener.

In order to discuss some points of general and lichenological interest I will refer to one of our commonest and most highly developed lichen-genera, namely Peltigera, the species of which are foliaceous.

In 1857 Speerschneider (27) described the structure of *P. scutata* Kbr. (which occurs in this country), mentioning the interesting ecological fact that it is calciphobe. *P. scutata* is characterised

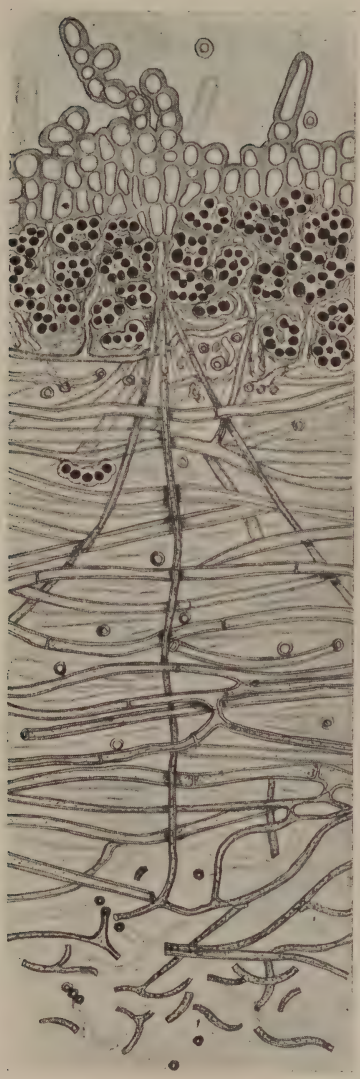

Fig. 1. *Pelrtigea canina.* Vertical section of thallus at right angles to margin. *a*, cortex; *b*, gonidia; *c*, medulla; *d*, hypothallus. The hypothallus is seen to be connected with the cortex by a fungal hypha. Magn. 225.

by the possession of a sorediate margin. Speerschneider's description is fairly accurate, though he considers that the outer cells of the cortex are dead cells. He records the development of the gonidia from the inside cells of the cortex much in the same way as does Elfving (10). Schwendener, giving an account of the structure of *P. canina* (L.) Hffm. in 1863 (22, III, p. 174), had little to add to Speerschneider's statements. He made some criticisms as regards the condition of the cortical cells and the origin of the gonidia, though he did not put forward his theory as to the dual nature of lichens till 1867. Numerous remarks may be found in literature touching on the structure of Peltigera, but of these many are either incorrect or only misleading. In a paper by M. and Mme Moreau in 1919 (18) an account is given of the structure of the Peltigeraceae. The authors distinguish a cortex, the mycelial elements of the gonidial layer, the medulla and the subterranean mycelium. The latter is figured and I find some difficulty in correlating the figures with anything I have seen in *Peltigera canina.* No portion of the thallus can, strictly speaking, be called subterranean except certain small portions of the rhizines which may penetrate a short distance into the soil, but these soil hyphae show no structural difference from the ordinary hyphae of the rhizines.

In a short paper published after his death by Tobler,

Strato (28) gives, by means of some very diagrammatic drawings, a truer picture of the tissues of *P. canina*. These tissues are upper cortex, gonidial layer, medulla, veins and rhizines. In two very diagrammatic figures he further differentiates correctly the medulla into an inner portion of long straight hyphae, and an outer portion of shorter and much twisted hyphae (28, fig. 1 and fig. 6). The latter are, however, not mentioned in the text. Hue, with his laboriously carried out observations, does not increase our knowledge of the structure of Peltigera to any extent.

The structure of *Peltigera canina* is briefly this (Text-fig. 1). The upper side has a continuous cortex consisting, in the mature parts of the thallus, of hyphae forming rows of fairly large and broad cells. These rows may consist of two to six cells and may be continued beyond the general surface of the cortex in the form of simple or branched hairs which form a kind of felt on the upper side of the lichen. Apart from these hairs the surface of the cortex is rather irregular. The walls of the cells are thick and there are no breathing pores. The cortical cells are living cells, and nuclei and cytoplasm can easily be observed. Though living, however, these cells have lost the power of further division. But they grow in extent considerably, thereby increasing the surface of the whole lichen. The cell-rows of the cortex are directly connected with the felt-like hypothallus of the underside or with hyphae of the medulla.

The gonidia forming a layer just below the cortex belong to the alga *Nostoc punctiforme* (Kütz.) Hariot, and are in groups embedded in a gelatinous sheath. Between these are to be found very fine and short branches of fungal hyphae which do not however get into very close touch with the actual gonidial cells.

The hyphae of the medulla run mainly in a longitudinal direction, that is to say, they radiate towards the margin which they strike roughly at right angles. Immediately below the hyphae of the gonidial layer the medullary hyphae are rather irregular in their course. Most of them, however, run longitudinally but many run at other angles. They are fairly closely packed. Gradually the hyphae are seen to run more regularly. Between the hyphae of the medulla there is much intercellular air-space, though the hyphae are very firmly interwoven, being cemented together by their walls over long distances. Their course is slightly but yet clearly wavy, the medulla thus consisting of a strong system of interconnected strands, the separate units of which in addition frequently anastomose, *i.e.* enter into cytoplasmic connection. The longitudinally running medullary hyphae together form a mechanical system not unlike the system of bast-fibres in the lime and other trees. The hyphae are cylindrical in section and have thick walls. The medulla is very thin

in portions between the veins and very thick where it forms one of the thicker veins. It is from the thicker portions of the medulla that the rhizines arise.

On the lower side of the thallus we find the hypothallus, which consists of loosely packed short-celled and much twisted hyphae, forming a kind of felt. This layer corresponds in every way to the hypothallus of the Pannariaceae and does not here deserve the name of "lower cortex."

The cells of the cortex are seen to be connected by long straight hyphae with the hyphae of the hypothallus. These connecting hyphae date from the actively growing period at the margin of the thallus. The hyphae elongate and the connection remains, the whole forming an important part of the mechanical system of the lichen.

Growth takes place at the margin, where cortex, medulla and hypothallus are soon differentiated. Near the margin the cortical cells measure 0·002 mm. in diameter. In an older portion of the cortex their diameter reaches 0·005 to 0·006 mm. As already mentioned, the surface of the whole lichen considerably increases by this growth in diameter of the cortical cells. The medullary hyphae apparently retain the power of growth for a considerable time, especially the hyphae in the neighbourhood of the gonidia.

The rhizines arise from the lower and thicker portions of the medulla. The inner core consists of hyphae running longitudinally, firmly cemented together and frequently anastomosing, and this core is surrounded by a loose layer continuous with the hypothallus. The apex of each rhizine remains active and spreads out according to the substratum the lichen is growing on. When not in touch with the substratum, or in a dry locality, the rhizines may be short and fluffy. In wetter localities and when in touch with mosses or old Peltigera thalli the rhizines may be longer and almost string-like and in that case their tips only open out into an attachment organ, made up of loose and spreading free hyphae completely covering leaf and stem of the moss without entering any of the living cells.

It is not difficult to make out the functions of the various parts of the thallus. The rhizines mainly absorb water. This they do chiefly at their apices or at points where their internal hyphae are exposed. The loose hyphae of the hypothallus do not absorb water. They will in fact not moisten when water is applied to them. Water is passed rapidly along the veins and then reaches the hyphae in the gonidial layer, and transpiration, at a slow rate, takes place from the cells of the cortex. Our knowledge of the interchange of food between alga and fungus is still very incomplete.

The genus Peltigera possesses three sets of special organs which are made up of both alga and fungus and they are thus organs of interest from the pure lichen point of view. These organs are cephalodia, soredia and isidia. Briefly these organs can be described thus. The *cephalodia* contain gonidia generically different from the normal gonidia of the particular lichen. They always belong to the Cyanophyceae. The *soredia* are small reproductive organs which reproduce the whole lichen. The *isidia* are outgrowths from the lichen thallus, fruticulose or foliaceous in shape, which have some physiological function other than that of reproduction.

First considering cephalodia—these occur invariably in the case of *P. aphthosa* (L.) Willd., being distributed over the upper surface of the thallus. They are small masses of foreign Nostoc-cells caught up and completely surrounded by fungal hyphae of the cortex and are attached by them to the cortical surface. Their function is unknown. It is significant, however, that their gonidia belong to the Cyanophyceae only and that here, as in all other cases, they occur only when the normal gonidia of the lichen are chlorophyceous. Possibly they may be concerned with the fixation of free nitrogen. Bitter (2) has described in the lichen *P. lepidophora* (Nyl.) Wain. the presence of cephalodia containing chlorophyceous gonidia though the ordinary gonidia of this species are also chlorophyceous. Linkola (16) was able to show that, according to their development, these so-called cephalodia are in reality only isidia. The algae of true cephalodia are caught up by the lichen-fungus from the outside; the gonidia of isidia are derived from the ordinary gonidial layer of the lichen. I have been able to follow out the development of Bitter's cephalodia in *P. lepidophora* and I can fully support Linkola in his view that they are isidia only and not cephalodia.

Of much greater interest are the soredia which, with us, occur only on the margin of the thallus of *P. scutata* and in small circular patches on the thallus of *P. canina* var. *erumpens* (Tayl.) Hue. I do not at the moment wish to say whether this is a variety of *P. canina* only or a separate species. In any case the use of the word "variety" seems most inappropriate here. We can either speak of a soredial condition of *P. canina* or of a soredial form. So "erumpens" should be looked upon either as a separate species or merely as a form or condition of *P. canina*. I cannot say that I have really made up my mind as to whether it is a separate species or not. I incline to the former view. The plant is small in size and has very small rhizines. The soredia are small groups of algae surrounded by a few hyphae and these are carried up in a gap of the cortex and gradually separate and ultimately give rise to fresh plants and are thus reproductive

organs which propagate the whole lichen thallus. I have not been able yet to observe how the cortex of this species is broken through for the first time when forming the soralia. I have no doubt from what I have seen so far in this species and in other soralia-bearing lichens that the hyphae of the lichen-fungus are most active in pushing up the algae and breaking through the cortex and thus giving them opportunity to divide and supply fresh gonidia for the formation of more soredia. Gonidial algae will generally divide and increase in numbers if allowed to do so by the lichen-fungus.

I wish to digress at this point for a moment in order to say a few words on the use of the term symbiosis, before continuing my remarks on soredia. The word symbiosis should be used in a very general sense only. Individuals of different species in intimate cellular contact with one another, and intimately dependent on one another, but without either organism being injured or killed by this close contact, may be said to be symbionts. Symbiosis then means a generally harmless but intimate at least cellular association between at least two individuals belonging to different species. Symbiosis is a generic term and if it becomes desirable to define the state of affairs in any one case more accurately a specific definition should be added. This has of course been done over and over again, but generic and specific terms are often used indiscriminately.

Schwendener defined symbiosis as being a state of parasitism of the fungus on the alga. Danilov (7) speaks of a disease caused by the fungus on the alga; Moreau also refers to the condition as one of a disease of the fungus comparable to the galling of Phanerogams by insects (18, p. 125): the fungus is rendered diseased by the intrusion of the alga. Nienburg (19) and others prefer the term helotism, or slavery. Elenkin (9) used the term endosaprophytism, indicating that the fungus ultimately devours the older algae. All these terms indicate antagonism between the two organisms though not to the point of death. Reinke, in using the term *consortium*, wished to define the relationship between the two organisms as that of two partners living peaceably together and working for the common good of the whole complex organism. These terms are specific and may be applicable in certain specific cases. But all cases are examples of symbiosis, which is a generic term. There is no question of the lichen not being an example of symbiosis. However we really do not know enough of the intimate relationship of the two partners to say in every case what specific name should be applied.

There is just one further point to be remembered. I include the physiological condition of all lichens in the term symbiosis.

But this condition has certainly not arisen only once in the transition from free-living fungus and alga to lichen. It is certain that it is of polyphyletic origin. We would for that reason expect some difference in the character of the "species" which form this "genus." The above-mentioned various attempts to define the state of affairs met with in lichens may be justified and be correct, but not necessarily for more than the particular lichen-species examined. It is impossible that they can all be applied to all lichens equally. I am inclined to believe that examples of most could be found among lichens, even to the galling of the fungus by the alga. Moreau, however, generalises, and from using this term to explain the condition met with in Peltigera applies it to that of other lichens. In this he is certainly incorrect.

Evernia prunastri (L.) Ach., a common fruticulose lichen, has been the subject of investigation by various authors. Danilov observed the presence of intracellular fungal hyphae in the gonidia of this lichen. Hence he spoke of the fungus as causing a disease of the algae. Nienburg (19) was able to confirm the facts of fungal penetration in this case. It is this which leads him, together with other observations, to use Warming's term helotism or state of slavery to indicate that the fungus can do with the alga what it likes. Recently Paulson and Hastings (20) examined the same species of Evernia and were quite unable to see any intracellular hyphae, though their observations bear the stamp of very careful and painstaking work. They examined young growing gonidia, thereby demonstrating a very interesting seasonal activity among the gonidia, but on that very account they may have missed the older algae which, according to Nienburg, are those mainly filled with intracellular hyphae. Some work carried out by Miss Ridler in the Cryptogamic Department of the University of Bristol seems, however, to confirm the truth of the observations made by Paulson and Hastings.

The following is to my mind what happens in the lichen. The fungal ascospore germinates and is at first without the algae which it requires as gonidia. Left to itself it would not normally grow up to form a lichen. If finally, however, it gets into touch with its own particular algae which stimulate the fungus to develop into the lichen, the fungus can grow up outside and independently of an organic substratum as the green algae supply the necessary organic food. The fungus, however, supplies water to the algae and, what is more important, it can store water and thus supply the algae with water for a longer period than these would otherwise have at their disposal. There are three things then that the fungus must do in order to allow the algae to grow properly. It must absorb water

efficiently, that is quickly; it must be able to store water and that means that the fungus must reduce transpiration, or, let us say, have it under control. Transpiration must be a noticeably slower process than that of absorption. If this mechanism does not work efficiently the algae will not flourish and will not be able to build up enough organic food and may even die, which would of course also be the end of the lichen-fungus. This threat reduces the activity of the fungus till it can just supply the water necessary for the green algae. So the growth of the algae depends on the efficiency of the fungus and the latter depends on the algae doing their part of the business. The presence of the algae stimulates the fungus to greater activity, but the latter is limited by the influence of the prevailing external conditions. The lichen-fungus cannot outgrow the gonidial layer, and the algae cannot outgrow the lichen-fungus under normal conditions. They work together. The beam of the balance is kept fairly horizontal. This is the normal type of symbiosis which we get in lichens, and it is regulated automatically by co-operation. This form of co-operation is not really more wonderful than the automatic balancing of green plant and colourless toadstool which we find in the forest. At the same time the association in the lichen is far more intimate. It is, however, not entirely and simply the sum total of the activities of a free fungus and free algae. Chemists have shown us that numerous lichen substances, occurring in neither constituent when free, are met with in the compound lichen organism. Tobler has shown experimentally that the hyphae of the lichen-fungus of *Xanthoria parietina* (L.) Ach. do not contain the acid characteristic of the species till they have entered into symbiotic relationship with algae (30, p. 427).

In a discussion on the theory of symbiosis Burgeff (4) in 1909 quotes Elenkin as speaking of a pair of scales, the position of the originally horizontal beam of which indicates the degree of balance as between alga and fungus. The pan, according to Elenkin, holding the fungus is permanently more depressed than that holding the alga, thus indicating the predominance of the former. Resting on his experience with the mycorrhiza in Orchids, Burgeff affirms his belief that symbiosis begins only as soon as parasitism is properly regulated. Not till then would, according to Burgeff, the beam of the balance take up a horizontal position. This form of symbiosis he would then look upon as mutualism.

I do not at all wish to imply that such a term as endo-saprophytism and other similar terms should be dropped. It is quite possible that older gonidia are devoured by the fungus in some cases. Experimental work is necesary to determine the exact nature of the symbiotic relationship in each particular case.

In a paper which is both stimulating and full of interest Church (5) discusses the nature of symbiosis in lichens. He shows to his satisfaction that the lichen-fungus is derived from a marine Floridean ancestor which lost its assimilating layer in a rockpool. This degeneration gave us the fungus and its mycelium of hyphae. Degeneration continued but was at one point arrested by the intrusion of chlorophyll-bearing algae which then became the slaves of the fungus, and thus we get the lichen. Church does not believe that fungus and algae came together and thus synthesised a lichen thallus, at first, of the simplest crustaceous type from which gradually all the highly differentiated forms of to-day have developed. He rather suggests that the crustaceous lichens of to-day are degenerate species developed from bigger fruticulose forms, directly descended from marine Florideans. Personally, I like to look upon *Xanthoria parietina,* a highly developed and well-equipped foliose lichen, as working its way out towards the sea—itself the end of a long line of land-plants, wherever these may have come from originally—and greeting the small phaeophycean *Pelvetia canaliculata,* the descendant of an equally long line of sea-plants; two races of high but different civilisations meeting. Church would, I imagine, look upon *Xanthoria parietina* as the prodigal son returning to his ancestral home—the sea.

I must now refer again to the soredia. These are reproductive organs. Kajanus (15) considers them to be due to the excessive growth of the algae, induced by moist conditions. There is no evidence at all that this is normally the case. The presence of soredia I would associate more generally with dry conditions, as Miss Smith also points out. The bark of trees is often covered with the white soredial masses of *Variolaria* (*Pertusaria*) *amara* Ach. and *V. globulifera* Turn. These places are markedly dry. The soredia are composed of loose tissue and this is as a matter of fact not even easily moistened during rain. The soredia do not become unduly moistened till they have been shed. The wind and small mites, etc., aid in the distribution of the soredia. What then brings about the formation of soredia? They are not simply shapeless gemmae, but are, as Reinke (21) pointed out, emphatically reproductive organs of a compound organism, the lichen. The lichen-fungus—in common with its free ancestors—is imbued with a reproductive impetus, and is ready to reproduce itself at any time should conditions become favourable. This reproductive impetus finds no outlet in many lichen-fungi as far as sexual reproduction of the normal Ascomycete is concerned. The still active reproductive impetus takes the form of a breaking through of the cortex by the fungus carrying with it the algae of the gonidial layer. One can very roughly say that the intensity

of soredial formation varies inversely with the occurrence of apothecia. The fungal hyphae remain automatically in touch with the algae and these increase automatically but slowly when carried up as soredia. In this way the reproductive impetus of the fungus is satisfied and the actual balance of fungus and alga inside the soredium is automatically regulated just as it is in the vegetative thallus.

Turning now to a consideration of isidia. The term isidium was at first applied to the coralline outgrowths on the upper surface of some of the saxicole Pertusarias which were originally comprised in the genus Isidium. The isidia are here minute, fruticulose, terete organs growing on a crustaceous lichen thallus. They occur plentifully also on *Parmelia saxatilis* (L.) Ach., *Umbilicaria pustulata* Hffm., and numerous other species. It is quite evident again that phylogenetic development has followed converging lines. Isidia are also found in the genus Peltigera. There is some difference of opinion as to whether the chief isidia-bearing form is a separate species or a variety of *P. canina* or *P. rufescens* (Sm.) Hffm. It has been given the name *praetextata*. I consider it a condition or state of *P. rufescens*; I am not sure whether there is not also a similar state of *P. canina*. Both Linkola and Wainio consider *Peltigera praetextata* (Flk.) Zopf to be a distinct species (16).

The upper surface of *P. praetextata* often exhibits cracks and the edge of these cracks then gives rise to small leaf-like structures. These are the isidia, which occur also near the margin of the thallus. The hyphae just below and just within the gonidial layer become meristematic and grow out. They form small knobs containing a few algae at first continuous with the ordinary gonidial layer surrounded closely by fungal hyphae. Gradually these small knobs grow up and ultimately form flat leaf-like expansions. These extend more or less in a horizontal plane and are orientated dorsiventrally. They are also, except for their stalks, completely surrounded by a cortex which is continuous with the cortex of the ordinary thallus. But the upper cortex is thicker, with a depth of two or three cells, than the lower which is only one cell deep. The algae are generally fairly evenly distributed between the two cortices. Does not the difference between upper and lower cortex remind one of the difference in structure of upper and lower side of a normal dicotyledonous leaf? The foliose isidia of *P. praetextata* imitate in their dorsiventral structure the leaf of a higher plant. The necessary carbon-dioxide required for assimilation may be supplied through the loose medulla of the main thallus which is continuous with the interior of the leaflets of the isidia. The formation of isidia is brought about by the presence of certain

conditions favourable to an increase in the activity of the lichen-fungus, which make it a more efficient partner in the lichen business. Isidia on Peltigera are found most commonly where conditions are moist. The fungus absorbs more water and the transpiratory surface is increased. The gonidia keep pace with this increase of surface. This is simply automatic co-operation and adjustment. Thus moist conditions in the end permit of an increase in the assimilating surface. Isidia are not reproductive organs, though if separated from their parent plant they have been observed to grow into bigger plants, thus reproducing the plant vegetatively. Kajanus(15) considers that isidia and soredia are both due to excessive activity on the part of the algal gonidia. Tobler, expressing the views of Strato(28), also considers that gonidia are the formative and driving elements in the formation of isidia. I have found that isidia are due to fungal activity in the first instance.

It is very important to realise that the lichen and not the alga alone or the fungus alone gives rise to the isidia. The two organisms work together. Increased activity is due to moist external conditions. It is possible that isidia may in some cases take on an absorptive function. This is, however, not very likely, as water would then probably be given off at the same rate at which it was absorbed, with no advantage to the lichen as a whole.

Generally speaking, there seems to be no doubt that the isidium is an expression of the tendency of the lichen thallus to increase to the utmost its capacity for carbon-assimilation allowing the gonidial layer to expand laterally. Reinke addresses the isidia as assimilators. All lichens seem to have such a goal in view or appear to be moving in that direction. The increase in surface area is controlled by the necessity for the good of the lichen as a whole to keep the beam of the balance horizontal. It is this tendency towards the improvement of assimilatory conditions which has produced foliaceous from crustaceous lichens, and further upright foliaceous, *i.e.* still dorsiventral, and ultimately fruticulose lichens. Some of the simplest crustaceous lichens show this tendency to increase their surface, *e.g. Rhizocarpon geographicum* (L.) DC., a saxicole crustaceous lichen which Miss Holt recently examined very carefully in my laboratory, shows this phenomenon very clearly. The margin of this lichen consists of loose fungal hyphae radiating outwards and very closely applied to the rocky substratum. A differentiation into various tissues cannot at first be made out. Gonidia are present in small numbers only and have clearly been picked up by the marginal fungal hyphae. As the margin advances these algae grow and divide. The growing algae stimulate the fungal hyphae to increased activity, and fungus and algae

gradually grow upwards away from the substratum. Small basalt-like pillars are formed which rest on the thin hypothallus which is directly applied to the substratum. Between the pillars are narrow gaps, giving the lichen thallus the characteristic chinked or areolate appearance always found in the typical saxicole crustaceous lichen. The immature undifferentiated, but most actively growing, part of the thallus I call the protothallus, the mature areolate portion the metathallus. The pillars of the metathallus are—as is well known—a wonderful arrangement for keeping the algae well supplied with water. The whole surface of the pillars, *i.e.* upper surface, and the sides especially, not being covered by the old scaly primary cortical cells like the upper surface, absorb water actively. A drop of water falling on to the lichen is drawn into the narrow cracks or chinks by capillary attraction and is then rapidly absorbed by the sides of the pillars. The inner tissues of these pillars now swell up and the cracks close up. The water has been absorbed by a big surface, but for transpiration with the cracks closed at first there is only available the upper surface of the pillars. This is also covered with a thick layer of the dead cells of the primary cortex. Transpiration is thus much slower than absorption and so water is stored and fungus and algae flourish. Certain portions of the protothallus do not succeed in picking up algae. They do not grow up but will in the end form apothecia and spermogonia. But I would not like to say which is cause and which effect.

We have here then the same simple symbiotic relationship between alga and fungus regulated automatically which we had in Peltigera. We see also the same tendency of the lichen to increase the assimilating and water-absorbing surface as much as external conditions will allow.

A short time ago I received from Mr F. J. Chittenden a few lichens from China. One of these was a big specimen of *Cladonia squamosa* (Scop.) Hffm. var. *muricella* (Del.) Wainio. This specimen exhibits most completely the height to which physiological differentiation can go in the lichen. The flat protothallus is gone but there remains the upright podetium of the metathallus perfectly differentiated into stem and leaf. The leaf or assimilator shows a very marked dorsiventral orientation. The loose-tissued lower side is well adapted for the admission of carbon-dioxide. These leaves show how near their goal the Cladonias have come. Permanently adverse conditions prevent the crustaceous *Rhizocarpon geographicum* realising this ambition beyond forming the pillars just described. Peltigera can only show now and again what is "in its mind" by developing isidia.

I hope I have succeeded in showing the lines along which the evolution of the lichen is proceeding. The fungus develops its

vegetative organs almost entirely inside its organic substratum away from the light. These organs are apheliotropic. The algae develop in the light. Associated with these green organisms the lichen-fungus has become positively heliotropic and has forsaken its organic substratum.

It is also, I hope, clear from what I have said that systematist and physiologist must co-operate in the study of the lichen, just as alga and fungus co-operate in the lichen itself.

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STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate I and 3 Text-figs.)

IV. SOME CEYLON CORDYCEPS.

By T. Petch, B.A., B.Sc.

In the *Fungi of Ceylon*, Berkeley and Broome enumerated five species of *Cordyceps*, two of which were new, viz. *C. Barnesii* and *C. dipterigena*. As was pointed out by Massee, one of the five records was based on a misidentification; the specimen attributed to *C. sobolifera* being *C. Barnesii*. Massee added two other species to the Ceylon list, but in both cases the identification appears to be incorrect. During recent years, further species have been collected, bringing the total known *Cordyceps* of Ceylon to ten. In addition, several species of *Isaria* are known, of which the perfect stage has not yet been observed.

The localities in Ceylon from which species of *Cordyceps* have been recorded are, at least as far as relates to the species found on the ground or in rotting wood, chiefly in the higher districts. It is possible that an observer stationed in the low-country might be more fortunate in obtaining these fungi there than I have been, but even at Peradeniya (1600 ft.) they have been very rare during the last eighteen years. I have only one record from Peradeniya, viz. a single specimen of *C. Barnesii*. This distribution coincides with that of the subterranean fungi, *Hydnangium*, *Rhizopogon*, and *Hymenogaster*; and one is inclined to associate it with the absence of those keen mycophagists, the termites, from the higher regions of the hill country.

Cordyceps dipterigena, *C. unilateralis*, *C. Blattae*, and "*Isaria crinita*," are invariably found attached to living leaves or stems. The first two of these have been collected in the low-country, and *I. crinita* at a medium elevation. When the first three of these occur on living leaves they are always attached to the under surface, and a similar condition prevails in the case of spiders attacked by *Torrubiella flava*, *Gibellula elegans*, etc., the

insect being fastened to the leaf by strands or pads of hyphae round its feet, or by a weft of hyphae from its body. It would appear to follow that the hyphae of the fungus grow out from the insect and fasten it to the leaf before it dies; otherwise the insect would fall off when it died. Consequently, it would appear that the occurrence of the insects in the position described is evidence against the theory that these fungi grow on their several hosts only after the death of the latter.

Cordyceps dipterigena, C. unilateralis, C. myrmecophila, and *Isaria crinita,* contrary to the more general rule in *Cordyceps,* develop from the perfect insect. *C. Blattae* might be included with these, as, although the cockroach bears fertile clavae in the nymphal stage, it is nevertheless an active stage.

C. unilateralis has been found in Ceylon on one occasion only, and then not by a mycologist; yet three specimens were obtained, one on each of three leaves. As, however, ants are gregarious, it might be expected that several would be infected at the same time. *C. dipterigena* has been collected on several occasions, and it is usually possible, when one has been found, to obtain several others, up to twenty, by a careful examination of neighbouring bushes. The latter fact suggests that the insects are infected when they are in close association, *i.e.* in the larval stage, and that the clavae do not develop until the insect is mature.

CORDYCEPS.

A. Perithecia immersed in the Stroma.

Cordyceps Barnesii Thwaites. This species (Plate I, fig. 1) was described by Berkeley and Broome in *Fungi of Ceylon,* No. 977, the name being suggested by Thwaites in honour of Mr R. Barnes, who first called his attention to it. The fungus occurs on cockchafer grubs, and it was apparently common in the days of coffee in Ceylon, when "grub" was one of the coffee-planters' enemies. There is an abundance of Ceylon material in Herb. Kew and specimens in Herb. British Museum and Herb. Peradeniya, all collected by Thwaites, while Beccari collected it in the Botanic Gardens, Peradeniya, when he passed through Ceylon on his way to Borneo. At the present day, however, it appears to be rare, and I have obtained only one recent specimen.

Berkeley and Broome's description is "Stipite cylindrico velutino: clavula cylindrica, apice sterili; conidiiophoris ramosis stilboideis candidis, capitulis globosis (no. 1120, cum icone). On larvae of *Melolontha.* Conidia ·0001 [inch] long."

The fungus (clava) attains a height of 6 cms., but it is not conspicuous. The stalk is fuscous or blackish brown, rather paler towards the base, the ascigerous part sordid reddish

brown, and the sterile tip pale yellow or whitish. The fungus consequently has a somewhat dingy appearance.

The stalk is cylindric, up to 2 mm. diameter and 4·5 cm. high, glabrous. The "minutely velvety" of the original description, and the strigose appearance depicted by Massee, relate only to that part of the stalk which is embedded in the soil and is consequently somewhat tomentose or clothed with fibrils. The head, or perithecial region, is sharply differentiated from the stalk, being abruptly thicker, 3–5 mm. diameter; it is 8–15 mm. long, with the upper and lower edges rounded and usually oblique, or incised on one side, not symmetrical. Above the perithecial region there is usually a sterile conical apex, up to 5 mm. long.

When fresh, the perithecia are completely immersed and the head is smooth, but in dried specimens the ostiola project slightly and the head is rough. The perithecia are conoid, 0·35 mm. deep, 0·15 mm. diameter, with a yellowish-brown wall. The asci are cylindric, capitate, very shortly pedicellate, eight-spored, 160–220 × 8–10 μ. The spores are linear, as long as the ascus, in a parallel bundle, and divide into part-spores which are very variable in length. In some asci the part-spores are 30–40 × 2 μ; in others, they are only 9–12 × 2 μ. This variation occurs both in Thwaites's specimens and in that recently collected. It appears to be not an uncommon phenomenon in the case of linear ascospores which divide into part-spores when mature.

The conidial stage of this species differs completely from that usually associated with *Cordyceps*. It was briefly described by Berkeley and Broome, and was figured by Massee, but that such a conidial stage can belong to a *Cordyceps* has been generally overlooked. The immature clavae bear scattered, white, stilboid conidiophores. These may be simple, up to 1 mm. high, or repeatedly branched at a wide angle, up to 4 mm. high, the branches terminating in ovoid, compact heads, 0·1–0·2 mm. diameter. The stalk of the stilboid conidiophore is composed of parallel hyphae; and these separate at the apex, or at the apices of the branches, to produce a normal *Stilbum* head of conidia. The conidia are hyaline, globose, 0·75 μ diameter, or oval, 1·5–2 × 0·75–1 μ, adherent in a solid mass. When the head is bearing perithecia, these stilboid conidiophores may still be present on the conical tip. A similar conidial stage occurs in *Cordyceps falcata* (Plate I, fig. 12).

In *Fungi of Ceylon*, No. 978, Berkeley and Broome recorded for Ceylon, *C. sobolifera* Berk., "on larvae of some lamellicorn insect at the roots of coffee-trees. Bolagodde." As previously noted by Massee, the specimens are *C. Barnesii*.

Cordyceps gracilis (Grev.) Dur. and Mont. A single specimen (Plate I, fig. 2), which appears to be referable to this species,

was collected at Hakgala. Unfortunately it was dug up somewhat carelessly and detached from its host, and further search for the latter was unsuccessful.

The available part of the stalk is cylindric, 5 cm. high, 2–2·5 mm. diameter. The head is subglobose, 4 mm. diameter, sharply differentiated from the stalk, smooth, the ostiola not projecting. The perithecia are totally immersed, crowded, flask-shaped with a rather long neck, 0·3 mm. diameter, 0·4–0·6 mm. long, the length increasing towards the apex of the head. The asci are 6 μ diameter, of the usual type, and the part-spores are cylindric, 4–8 × 2 μ.

In general appearance this agrees with *C. gracilis*, but its colour when fresh was white, with a faint pinkish tinge on the head. The ostiola were not visible, and it was thought that the specimen was immature. The dry specimen is brown to yellow-brown, the head punctate with darker ostiola.

C. podocreoides von Höhn., from Java, is somewhat similar, but has stalks expanding upwards, and heads rough with projecting ostiola. Its perithecia are oval, 0·4 × 0·3 mm., and its part-spores, 8 × 1 μ. Von Höhnel described the colour as "from ochre yellow becoming brown," but it has to be borne in mind that, although he collected in Java, his specimens of *Cordyceps* were chiefly old specimens previously collected by other workers.

Möller, who gathered *C. gracilis* in Brazil, stated that it was loam-brown, with a slight reddish tinge on the head of one specimen.

C. gracilis is usually described as brown. Whether it is white at any stage has not been recorded, as far as the available literature indicates. Another possible difference from the Ceylon specimen is the size of the part-spores. The Tulasnes described the part-spores of *C. gracilis* (*entomorrhiza*) as 6·5–8 × 4 μ, a much broader spore than in the Ceylon species. However, they figured the part-spores of an Algerian specimen, and the dimensions of those in the figure are quite evidently not as stated by them.

Cordyceps coccinea Penz. and Sacc. This species, which was originally described from Java, has been found at Hakgala, Ceylon, on a coleopterous larva in decaying wood. Several clavae arise from the one larva.

The clava (Plate I, fig. 3) is up to 13 mm. high, with an orange-red head, and a stalk of the same colour, becoming paler below. The stalk is terete, glabrous, 0·3–0·4 mm. diameter, becoming horny-looking and dark red-brown when dry. The head is ovoid-cylindric, 3–4 mm. high, 1·25–1·75 mm. diameter, rough with rounded protuberances, up to 0·15 mm. high, in which the ostiola are situated. In section, by transmitted light, the peri-

pheral layer is yellow-brown. The perithecia are immersed, crowded, elongated flask-shaped, 0·35 mm. high, 0·1 mm. diameter. The asci and spores are of the typical *Cordyceps* character, the part-spores being cylindric, 2–4 × 1 μ.

This differs from *C. militaris* in its immersed perithecia. The perithecia in the Ceylon specimens are more crowded than in Penzig and Saccardo's figure.

Cordyceps dipterigena B. and Br. This species was described by Berkeley and Broome in *Fungi of Ceylon*, No. 980, as "Pallida, stipite cylindrico; capite globoso; ostiolis inconspicuis. Sept. 1864. About 1½ inch high." The latter figure is probably a misprint for half an inch. Cooke, *Vegetable Wasps and Plant Worms*, p. 226 (1892), refers to this species, but he does not appear to have seen a specimen, as he quotes the height as an inch and a half without comment.

Massee (in *Ann. Bot.* IX, p. 20) gave a fuller description as follows: "Gregarious; stems simple, ½–1 cm. high, 1 mm. thick, cylindrical, smooth and even, pallid, head globose, smooth, pallid, about 3 mm. across; asci cylindrical, narrowed below into a long, slender pedicel, apex capitate, 8-spored; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, multiseptate, slightly constricted at the septa, and apparently always breaking up into the component cells, which are linear-elliptic, ends narrowed, truncate, hyaline, 10 × 1·5 μ, before leaving the ascus. On dipterous insect. Ceylon (Thwaites). Type specimen in Herb. Kew., examined." Massee figured two clavae arising from an adult fly, but as far as can be determined, they are shown as growing from the under surface of the insect, which is the reverse of the usual position.

This species has been found on several occasions in the jungle at Hakgala (5600 ft.), always on flies of the genus *Mydaea*. The dead insects are situated on the under side of living leaves, or on small twigs, to which they are attached by a fimbriate, rather coarse, rufous brown border of mycelium. It has also been found at Ratnapura, in the low-country, on a fly of the same genus; and one of Thwaites's specimens is also from the low-country (Pasdun Korle).

Typically, the dead fly bears two perithecial clavae (Plate I, fig. 4), symmetrically situated, one on either side of the thorax, and a conidial clava from the tip of the abdomen. The conidial clava, however, is often absent. I have gathered a specimen with three immature perithecial clavae arising from the thorax, but have not met with one having any greater number. As a rule the clavae are simple, but the specimen from Ratnapura bears two immature perithecial clavae, one of which has two short lateral branches.

The perithecial clavae are up to 6 mm. high, and consist of a well-defined stalk, about 0·3 mm. diameter, and a flattened-globose head, up to 2·5 mm. diameter. The stalk may be so short that the head appears to be sessile, and, in general, the long-stalked examples have the smaller heads. Immature examples are pallid or greyish white, but when mature the stalk is dark brown to black, longitudinally fibrillose, usually expanding upwards, while the head is yellow-brown to red-brown, glabrous, with darker, subtranslucent, scattered ostiola which may or may not project. The head is sharply differentiated from the stalk, and may have a flat base, or is sometimes umbilicate below.

The conidial clava is usually longer, up to 2 cm. long, and 0·25 mm. diameter, almost equal. At first it is brown with a white bloom, but becomes dark brown to black, grey at the apex, usually irregularly bent in the upper part. Conidia are present in the early stage, before the clava has become dark brown; they are clavate, or almost cylindric, 6–9 × 1·5–2 μ, and are borne on cylindric, verrucose basidia, 16 × 2 μ, which form a continuous external palisade layer.

In the larger specimens the head is generally flattened-globose, even, with the margin uniformly rounded above and below; but examples occur which are verrucose with strongly projecting ostiola, and others in which the vertical edge is grooved or fluted. The specimens with smaller heads show more variation. In several examples the head is barrel-shaped, *i.e.* taller than usual relatively to the breadth, with a convex, vertical side and a flat top; or it may be of the same general shape, but contracted upwards so that the top is smaller than the base (Plate I, fig. 5). In these latter forms, the ostiola are confined to the flat top, and the fungus is then *C. Ouwensii* von Höhnel, which is certainly identical with *C. dipterigena*. In one extreme variation the head consists of a digitate group of six, almost distinct, perithecia (Plate I, fig. 6).

The perithecia are immersed, vertical, crowded, elongated oval or obtusely flask-shaped, up to 0·8 mm. high, 0·25 mm. diameter, occupying almost the whole of the head, except for a small white region at the base. The wall of the perithecium is thin and hyaline. The asci are cylindric, capitate, 250–500 μ long, 5 μ diameter, and contain eight filiform spores, almost as long as the ascus, in a parallel bundle. The part-spores are narrow-oval, ends obtuse, 4–6 × 1–1·5 μ. Massee's measurement of the part-spores appears to be too large, while his figure of the perithecia has no resemblance to reality.

In Herb. Kew, *sub Cordyceps dipterigena*, there is a specimen from Ceylon—a fly which bears nine immature perithecial

clavae. This was marked by Massee, "not *dipterigena*," and it is apparently the Ceylon specimen referred by him to *C. albella* (B. and C.). It was named *C. Thwaitesii* by Lloyd, but, as Thaxter has pointed out, it is *C. dipterigena*, though it differs from all other Ceylon specimens in having such a large number of perithecial clavae. Like the recent Ceylon specimens, it is on a species of *Mydaea*.

Massee (*loc. cit.* p. 23) also recorded for Ceylon, *C. armeniaca*, on a coleopterous insect. The Ceylon specimen in Herb. Kew appears to be *C. dipterigena* on the remains of a fly.

In *Trans. Brit. Myc. Soc.* VII, p. 28 (1921), I suggested that *C. coccigena* (Tul.) Sacc. really grew on a fly and was identical with *C. dipterigena*. I have since found that the similarity of the two species was noted by von Höhnel.

Specimens of *C. dipterigena* are frequently parasitised, either by another Hypocreaceous fungus, *Byssostilbe tomentosa* Petch, or by a Hyphomycete, *Sporotrichum album* Petch.

C. muscicola Möller would appear to be identical with *C. dipterigena*. Möller's figure shows six clavae arising from one fly.

Cordyceps myrmecophila Ces. This species was recorded for Ceylon by Berkeley and Broome in *Fungi of Ceylon*, No. 979, from Thwaites 1218, *cum icone*. They gave a description of the species, as follows: "*C. myrmecophila* Ces. (*sub* Hypocrea); Rab. (no. 1033). Ochroleuca: stipite filiformi tenacello; clavula ovoidea ad basin sterili, superne costata acutiuscula, e peritheciorum summo ostiolo, gibberulosa. On dead ants."

There is no Thwaites's specimen in Herb. Peradeniya, and none has been collected recently. The figure (Plate I, fig. 7) shows a specimen, 3 cm. high, with a flexuose stalk, 0·2 mm. diameter, and an ovoid, somewhat pointed, head, 3·5 mm. high, 1·5 mm. diameter. The whole fungus is pale yellow. The coloured drawing shows the head smooth, but a separate pencil drawing, unfortunately not enlarged, shows longitudinal ribs and projecting ostiola.

The description given by Berkeley and Broome does not coincide with that in Saccardo, *Syll.* II, p. 586, but is the same as that quoted by them in *Ann. Mag. Nat. Hist.* Ser. 2, VII, p. 186 (1851), when recording the occurrence of *C. myrmecophila* on an Ichneumon, at Leigh Wood, Somerset. It was not drawn up from the Ceylon specimen, as might be imagined from its inclusion in the *Fungi of Ceylon* without quotation marks.

In shape, the Ceylon drawing is similar to the figure of *C. australis* Speg., given by Möller, and that of *C. depokensis* Koord.

Cordyceps unilateralis (Tul.) Sacc. var. **javanica** von Höhn. Three examples of this species were collected together at Anur-

adhapura, in the low-country, on ants attached to living leaves. A single clava arises in each case from the head of the insect. The insect is sparsely covered with brown mycelium which fastens it to the leaf chiefly at the feet (Plate I, fig. 9).

The clava is up to 12 mm. high, thin and flexuose, 0·4 mm. diameter below, tapering upwards, black or black-brown and minutely tomentose or bristly below, ashy in the upper half. The perithecial discs or plates are laterally attached, and situated on the lower half of the clava. One specimen has a single perithecial plate, another has two, while the third has four, three on one side and one on the other, situated 2·5–4 mm. from the base. The discs are black, glabrous, circular, 0·9 mm. diameter, 0·4 mm. thick, with a sharp upper edge, contracted below and sloping inwards to the point of attachment: in some cases they are slightly curved round the clava. The upper surface is slightly convex, tuberculate with close-set tubercles, 0·05–0·1 mm. diameter. Internally the discs are white. The perithecia are conical or flask-shaped, 0·2 mm. deep, 0·1 mm. diameter, with a yellow-brown wall. Unfortunately the available examples are immature.

The outer layer of the disc is parenchymatous, and by transmitted light the "cell walls" appear as a coarse irregular network, with meshes 8–20 μ broad, divided by thinner lines into smaller meshes.

The upper part of the clava bears conidia. These are hyaline, oval, 3–5 $\times$ 1 μ, borne on basidia having a total height of 24 μ and consisting of an oval base, 8 $\times$ 4 μ, bearing a slender, almost equal, sterigma, 1 μ diameter and up to 16 μ long. The conidial stage of this *Cordyceps* is consequently *Hirsutella*.

The Ceylon specimens agree with von Höhnel's figure and description, except that his specimen had much more pronounced tubercles or perithecial elevations. *Isaria myrmicidae*, in Lloyd, *Mycol. Notes*, No. 62, p. 915 (1920), would appear to be the conidial stage of this species.

Cordyceps Blattae Petch, n. sp. This species has been collected at Hakgala on two occasions, on a cockroach (*Blatta germanica*) attached to the underside of living leaves. A slight covering of brown mycelium overruns the insect and fastens it to the leaf.

The clava (Plate I, fig. 8) is cylindric, 1 cm. high, with a very short sterile base, 0·5 mm. diameter, from which it expands upwards regularly to a diameter of 1 mm. at the rounded apex. It is grey or lavender, the tissue being dark red-brown, covered with a grey or lavender pruina. The substance of the club is rather soft and viscid, and shrinks as it dries, so that the originally even, unicolorous clava becomes covered with minute,

red-brown, longitudinal protuberances arranged in vertical lines. In section, by transmitted light, the outer layer of the clava is purple-red.

The perithecia are immersed, conoid, 0·2 mm. high, 0·15 mm. diameter, with ostiola scarcely projecting. The asci are 100–130 × 8–12 μ, cylindrico-clavate, or narrow clavate, with or without a tapering pedicel, four- or eight-spored, the apex of the ascus being slightly thickened, but not capitate. Paraphyses are absent.

The ascospores (Plate I, fig. 14) are in a parallel bundle, spirally twisted, but the individual spores do not extend from the base to the apex of the ascus. As a rule, two reach the apex of the ascus and one extends downwards towards the base. They are elongated fusoid, 50–80 × 3–4 μ, usually acute, hyaline, multiseptate, with strong septa 5–8 μ apart.

It will be evident that the ascus and ascospores are quite different from the typical form in *Cordyceps*. The ascus is clavate with a slightly thickened apex, instead of cylindric with a capitate apex, and the spores, instead of the usual parallel bundle of linear spores, terminating at the same level, end at different levels and are elongated-fusoid. From the shape of the spores, it would seem improbable that they divide into part-spores. The spores and asci are those of an *Ophionectria*, not those of a *Cordyceps*, and the fungus may be regarded as an *Ophionectria* having perithecia embedded in a vertically-elongated stroma.

There would appear to be some probability that *Cordyceps unilateralis* may have similar asci and spores. Von Höhnel's illustration shows spores with well-developed septa, and a spore-bundle terminated by the tip of a single spore, but unfortunately only the end of the spore-bundle is figured. The figure was not drawn by von Höhnel. From von Höhnel's description, however, it would seem that all the spores were almost as long as the ascus. Another species described by von Höhnel, *C. rhizoidea*, has eight spores, each about half the length of the ascus, in an irregular bundle, and thus resembles *C. Blattae* in that respect, but the spores are different in shape and continuous.

B. Perithecia superficial.

Cordyceps falcata Berk. A species which appears to agree with *C. falcata* Berk. has been collected on several occasions at Hakgala on a coleopterous larva in rotting logs. The Ceylon specimens are smaller than those in the type from India.

The clavae (Plate I, figs. 10, 11) emerge through the holes made by the larvae. The perithecial clava is up to 2 cm. long, 1–1·5 mm. diameter at the base, cylindric or compressed, usually curved, tapering upwards to an acute apex, minutely tomentose,

white, becoming pinkish or reddish. The perithecia are superficial, usually developing in a continuous group, two or three millimetres above the surface of the wood, on the convex side of the clava or encircling it, but in the latter case they are more numerous on the convex side than on the other. In some instances scattered perithecia occur, apart from the main group. Massee's statement that the barren areas on the clava in the type are due to the fact that the perithecia have fallen off is incorrect, if the Ceylon and Indian species are identical. Barren clavae, *i.e.* clavae which have not yet developed any perithecia, are generally common. The clavae which are producing perithecia have a sterile tip, 2–10 mm. long.

The perithecia have a pinkish tinge when fresh, but become reddish brown when dry. They are ovate, up to 0·6 mm. high, 0·4 mm. diameter, with the apex somewhat narrowed and produced, and are slightly tomentose. They may be loosely adherent to one another laterally, but are not immersed in the stroma. The asci are cylindric, 340–440 × 8–10 μ, and the ascospores divide into part-spores within the ascus. In one collection, the part-spores are 4–8 × 1·5 μ, in another 8–12 × 2·5 μ, cylindric with rounded ends. In the latter, the part-spores were extruded from the perithecium in a yellowish drop.

The conidial stage (Plate I, fig. 12) similarly emerges from the beetle-boring as a tuft of short, branching, much-divided conidiophores. As a rule, these are rigid and short, but in some instances they are lax and up to 2 cm. long. The conidiophore, in general, originates on the larva as a single stalk, and branches when it reaches the exterior of the wood, but in the longer lax forms, branching only occurs at some distance above the surface. These latter forms are generally found on the lower surface of the log, and the difference is no doubt due to greater humidity in that situation. The conidiophore divides at a wide angle, and each branch terminates in a minute, white or yellowish, globose or ovoid, solid, glabrous head. The conidia are hyaline, oval or subglobose, 1·5–3 × 0·75–2 μ. The type of conidiophore is thus stilboid, and in this respect *C. falcata* agrees with *C. Barnesii*. If the perithecial clava is kept in a damp chamber, it develops the stilboid conidial form from the sterile apex. *Stilbum ramosum* Peck, found on similar larvae, would appear to be a parallel species.

According to my notes, there are specimens of this species, collected by Thwaites, included under *C. militaris*, in Thwaites 341 in Herb. Kew.

Cordyceps translucens Petch, n. sp. This species was found at Hakgala, among dead leaves, on a larva of a coleopteron. Several clavae arise from the one larva.

When fresh the clava (Plate I, fig. 15) is hyaline and translucent, with the central portion of the stalk and the contents of the perithecia appearing white and opaque. When dry it becomes amber-coloured or yellow-brown, and horny. The total height is up to 1 cm. The stalk is stout, erect, or curving upwards, 1 mm. diameter. The head is well differentiated from the stalk, globose or ovoid, up to 2·5 mm. high, 2 mm. diameter, bristling with strongly-projecting perithecia. The perithecia are superficial, broadly conoid or flask-shaped, 0·5 mm. high, 0·3 mm. diameter, with a cylindrical ostiolum, 0·05 mm. high and broad. A few isolated perithecia may occur on the stalk. The perithecia are united laterally by a slight weft of mycelium, the upper half being free and glabrous. The asci are cylindric, capitate, 4 μ diameter, with eight spores of the normal type, and the part-spores are cylindric, 6 × 1 μ.

Cordyceps pruinosa Petch, n. sp. This species was collected by Thwaites at Nuwara Eliya (No. 341 in part) and was assigned by Berkeley and Broome to *C. militaris*. There are specimens of that gathering in Herb. Kew and Herb. Peradeniya. I have a recent specimen, on a cocoon, but the clavae are immature. The type was said to be on pupae.

According to Thwaites, the clavae (Plate I, fig. 13) were bright crimson when fresh. The specimens in the Peradeniya Herbarium vary in height from 1·5 to 4·75 cm. The stalk is about 0·5 mm. diameter, and the head narrow-clavate or subcylindric, acute above, 7 mm. high, 1·5 mm. diameter. The stalks of the herbarium specimens still bear a red pruina, and the same red pruina occurs between the apices of the perithecia. The red colour changes to violet with caustic potash.

The perithecia are narrow-oval or ovoid-cylindric, 0·4 mm. high, 0·1 mm. diameter, with a conical apex, superficial, closely crowded together. The wall of the perithecium, by transmitted light, is pale yellow, with a vivid crimson apex. The asci are 4–6 μ diameter, of the normal type, eight-spored, and the part-spores, cylindric, 6 × 1 μ.

In the recent example, the cocoon bears about ten immature clavae. These are crimson, narrow-clavate or almost linear, up to 1 cm. long and 0·1–0·4 mm. diameter, strongly longitudinally fibrillose. On one of these the perithecia are just developing.

This species would appear to differ from *C. militaris* in the fibrillose immature clava, and the red pruina when mature.

ISARIA.

The conidial stages of the various species of *Cordyceps* are not in all cases co-generic with *Isaria farinosa* (Dicks.) Fr., the conidial stage of *Cordyceps militaris*. As already stated, the

conidial stages of *C. Barnesii* and *C. falcata* are compound Stilbums, occurring in the former on the immature perithecial clava, and in the latter independent of the perithecial clava. Further, the conidial stage of *C. unilateralis* is a *Hirsutella*, while that of *C. dipterigena* does not appear to fall into any genus yet described. It is consequently to be expected that an examination of the "Isaria" stages of the various species of *Cordyceps* would show that they belong to a wide range of genera of the *Hyphomycetae*. The examination should, of course, aim at determining the character of the ultimate branches of the conidial stroma and the mode of attachment of the conidia.

The following notes have been made on several species of *Isaria* which occur in Ceylon on insects, but of which the perithecial form has not yet been discovered.

Isaria Sinclairii (Berk.). This, the largest *Isaria* yet found in Ceylon, occurs fairly frequently at Hakgala on *Cicada* pupae, usually growing in clusters from the insect (Text-fig. 1). It is up to 6 cm. high, with a white stalk up to 2·5 mm. diameter below, branching above, the branches bearing ovoid, irregular, loose heads up to 1 cm. high and 5 mm. diameter. The conidia are oblong-oval, ends sometimes acute, hyaline, continuous, 8–10 × 2–3 μ, on basidia which are borne in clusters, either surrounding the conidiophore or terminal. The basidia are broadly flask-shaped, about 6 μ high, and 3 μ diameter below, the basal part being subglobose. It belongs to the section *Verticillium* of Vuillemin, and it does not appear to differ from *Isaria arbuscula* Hariot from Mexico, and *I. Hariotii* Arnaud from Madagascar, both of which have the same type of conidiophore, and conidia, 7–10 × 2–3 μ, and 5·5–7 × 2·5–3 μ, respectively.

Fig. 1. *Isaria Sinclairii*, on a cicada pupa, × $\frac{3}{4}$.

Von Höhnel described *I. amorpha* on a cicada in Java, but that species is said to have spores only 3–4 × 1–1·5 μ. The *Isaria* form known as *Cordyceps Miquelii* (Tul.) Sacc., on *Cicada* pupae in Brazil, has cylindrical conidia (*fide* Cooke), but is

insufficiently described. *C. sobolifera* Tul., on *Cicada* pupae in the West Indies, appears to be different, as far as can be determined from the published descriptions. The Ceylon species appears to be identical with *C. Sinclairii*, on *Cicada* pupae in New Zealand, the conidia of which are said to be oblong, and 7 μ long; but it would seem probable that all the species of *Isaria* with large conidia which have been recorded on cicadas are the same.

Isaria sp. on Lepidoptera. This species occurs at Hakgala on pupae of *Agrotis*, etc. It is up to 4 cm. high, with a lemon-yellow stalk and a white, divided head. The stalk becomes dull brown when dry, but still shows the yellow colour when mounted; it is about 0·5 mm. diameter, longitudinally fibrillose, branching above, the branches being suberect and each terminating in an ovoid head of contiguous branchlets. The yellow branchlets give off hyphae, 2 μ diameter, on which flask-shaped basidia, $6 \times 2{\cdot}5\ \mu$, are borne in clusters, either surrounding the hypha, or terminally. The *Isaria* heads are thus composed of spheres of basidia and conidia, about 40 μ diameter. The conidia are oblong-oval, or oval and inequilateral, or cylindric, sometimes curved, $3–4 \times 1–2\ \mu$. The type of conidiophore at first sight appears to be that of *Beauveria*, but the characteristic sterigmata of the latter genus are absent, the spores being apical on the basidium and (as observed) solitary or in a short chain of three or four. In the larger specimens, the main stalk may be clothed with these spheres for half its length.

This species would appear to resemble *Isaria tenuipes* Peck. Pettit stated that the latter species had basidia in whorls or opposite, after the type of *Verticillium*, but he gave the spores as oval to globose, $2{\cdot}5–3{\cdot}5\ \mu$, in a spherical cluster or sometimes an irregular chain at the apex of the basidium. The Ceylon specimens would be assigned to *Spicaria*, from the fact that the conidia may be in chains; but it may be considered doubtful whether it will be practicable to maintain as distinct groups *Verticillium* forms and *Spicaria* forms of *Isaria* on that character.

Isaria sp. on Lepidoptera. This species has been taken on a caterpillar and on cocoons at Hakgala. It is white, up to 7 mm. high, with a slender stalk, 0·15 mm. diameter, branching profusely but with branches often widely separated from one another, each branch terminating in a loose head of plumose branchlets. The branchlets are covered with stalked conidiophores, up to 50 μ high, each bearing a sphere up to 40 μ diameter. These spheres are clusters of basidia, as in the foregoing species, from which this differs in having the majority of the spheres terminal on short, rigid conidiophores perpendicular to the branchlet. The conidia are oval or subcylindric, curved in one aspect,

4 × 1 μ. In the arrangement of the conidiophores this species resembles *Verticillium Barbozae* Vincens, as figured in *Bull. Soc. Myc. France*, XXXI, plate IV. Vincens stated that he had not been able to find more than one spore at the apex of a basidium, and that nothing in the appearance of the spores favoured the supposition that they were formed in chains; hence the fungus was not a *Spicaria*. In the Ceylon species, however, the conidia may occur in short chains.

Isaria sp. on Lepidoptera. I have this form on a larva in rotting wood from Hakgala, and on a Tineid case from Peradeniya. In the latter the clubs arise round the mouth of the case. The clavae are scattered, simple, up to 5 mm. high. The stalk is slightly yellowish, about 0·2 mm. diameter at the base, tapering upwards to about half the height of the fungus, where it passes into the head and is continued to the apex as an unbranched columella. The head is narrow-clavate, or narrow-cylindric, 2·5 mm. high, 0·4 mm. diameter, white, and the conidia are narrow-oval, 4–6 × 1·5 μ. The columella gives off hyphae 2·5 μ diameter, which bear flask-shaped basidia, up to 10 × 2·5 μ, in whorls, the conidia being produced terminally in chains. This does not appear to agree with *Isaria Tinearum* Speg.

Isaria sp. on Orthoptera and Lepidoptera (Text-fig. 2). I have collections of this form on a grasshopper, on a cricket, on cocoons of *Thosea recta*, and on a caterpillar of *Homona coffearia*. Whether these all belong to the same species or not may be regarded as uncertain.

Fig. 2. *Isaria* on locustids, natural size.

The insect is usually covered with a thin, white or cream-coloured film of mycelium, which tends to become glabrous. From this there arise numerous Isarias, each consisting of a cream-coloured or brownish white stalk, up to 2·5 mm. high, 0·5 mm. diameter, expanding upwards, simple or branched, and terminated by a globose, white or pale yellowish head, up to 2 mm. diameter. The heads appear compact, but are powdery on the upper surface, which consists

of loosely intertwined hyphae, bearing conidia laterally. The conidia are oval, often inequilateral, 3–4 × 1·5–2·5 μ.

HIRSUTELLA.

Hirsutella Saussurei (Cooke) Speare. This species (Text-fig. 3) occurs throughout the tropics on hornets, and is well-

Fig. 3. *Hirsutella Saussurei*, on *Vespa cincta*, natural size.

known in all but name. Lloyd refers to it as *Isaria crinita*, the first specimen of this type discovered having been considered part of the insect, which was named *Vespa crinita*. Speare has shown that it belongs to the genus *Hirsutella*, and has given it the name cited above, on the assumption that it is identical with *Isaria Saussurei* Cooke, which was figured, but not named, by Saussure in 1853. According to Cooke, however, the hairs or filaments of *I. Saussurei* are orange, whereas those of the Ceylon fungus are dark brown or black.

Only one collection of this species has been made in Ceylon,

viz. on *Vespa cincta*, Badulla, 1903, by Mr G. Brown. In these specimens the clavae consist of long, black, rigid hairs, radiating in all directions from the body of the host. These hairs are up to 5 cm. long, and over sixty of them arise from one insect. Like the flies attacked by *Cordyceps dipterigena*, the host insect settles on some plant, to which it becomes attached by brown mycelium; while if one of the hairs comes in contact with a leaf or stem, it becomes united to it by a brown pad of mycelium, from which new black hairs may arise. The black hairs are synnemata, composed of longitudinally parallel hyphae, 2–3 μ diameter. They bear basidia, consisting of an ovoid base, about 12 μ high and 7 μ diameter, bearing a single sterigma, 2 μ diameter below, tapering upwards. My specimens are old and mouldy, and do not show conidia or complete sterigmata.

Hirsutella clavispora Petch; *Trichosterigma clavisporum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium covering the insect in a matted glabrous sheet, and spreading out in a fimbriate margin over the substratum. Clavae arising from the mycelium, erect, terete, simple, up to 8 mm. high, 0·35 mm. diameter below, tapering upwards, brownish white (dry), smooth. Basidia with an ovate base, up to 8 μ high, 2–3 μ diameter, rounded or attenuated above, bearing a rigid, simple, filiform sterigma, 5–9 μ high. Conidia hyaline, continuous, clavate, 4–8 $\times$ 1–1·5 μ. On a caterpillar attached to a living leaf, Peradeniya, January 1912 (Plate I, fig. 16).

This species does not appear to be related to *Torrubiella ochracea* Pat., the Ceylon analogue of *Cordyceps Sphingum*, as *T. ochracea* has verrucose conidia on the hyphae of the stroma.

Hirsutella arachnophila Petch; *Trichosterigma arachnophilum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium covering the body of the insect and forming a flattened pulvinate, pale yellow, somewhat spongy, tomentose stroma with a fimbriate margin. Clavae arising from the stroma, pallid yellow, cylindric, up to 4 mm. high, 0·15 mm. diameter below, tapering slightly upwards, smooth, simple. Basidia scattered or crowded, globose, 3 μ diameter, or subglobose, up to 6 $\times$ 5 μ, each bearing a single rigid, simple sterigma, about 2 μ long. Conidia narrow-oval, continuous, ends acute, 4–8 $\times$ 2 μ. On spiders attached to living leaves, Hakgala, March 1922; Peradeniya, March 1909; Peradeniya, March 1917. This species is the conidial stage of *Torrubiella flava* Petch. The specimen from Peradeniya, March 1909, differs in colour, being lilac grey. A similar colour difference occurs in *Gibellula elegans* P. Henn., which is also parasitic on spiders.

Hirsutella citriformis Speare; *Trichosterigma attenuatum* Petch, *Trans. British Myc. Soc.* VIII, p. 215. Mycelium scanty,

brownish, over-running the host insect. Clavae arising from the body or legs of the insect, usually from the joints, or along the margins of the wing covers. Clavae pale brown (dry), up to 6 mm. long, 0·2 mm. diameter below, tapering upwards to 0·08 mm. diameter, rigid, slightly inflated at the apex, terete, smooth, bristling with hyaline sterigmata when magnified. Basidia oval or flask-shaped, 8–10 × 3 μ, attenuated into a rigid, simple sterigma, up to 26 μ long, 1·5 μ diameter at the base, tapering upwards. Conidia hyaline, continuous, oval or lozenge-shaped, usually acute at each end, 6–7 × 3–5 μ. On a Pentatomid on bark, Hakgala, May 1912. The insect in the only available specimen bears more than forty clavae, but many of them have been broken (Plate I, fig. 17).

Hirsutella floccosa Speare. An example, apparently of this species, was gathered at Hakgala on a leaf hopper, March 1922. Speare states that this species differs from other species of the genus in that the synnemata are merely wart-like outgrowths arising from an external cotton-like subiculum. In the Ceylon example the wart-like outgrowths are lacking. The insect is sparsely covered with white mycelium which spreads from it over the leaf, and the basidia are situated, rather widely separated, on the hyphae. The hyphae are hyaline, 2–3 μ diameter, thin-walled, regular, and septate. The basidia are 5–14 μ high, 3 μ diameter, flask-shaped, tapering into the simple bristle-like sterigma, which is 3–10 μ long. The conidia are narrow-oval, 4 × 1·5 μ, but apparently immature.

GIBELLULA.

Gibellula elegans P. Henn. This species is common on spiders attached to living leaves. The whole fungus may be yellow, or the stroma yellow and the clavae pinkish or flesh-coloured, or the stroma yellow and the clavae lavender. In the latter case, the lavender colour ultimately fades, leaving the clavae pale ochraceous and the conidial heads ashy or whitish. There are no evident morphological differences between these colour forms. The conidiophores may occur on the stroma as well as on the clavae; on the latter, owing to their peculiar origin from loops of hyphae which are stouter than the hyphae of the clava, they have the appearance of being another fungus parasitic on the clavae. The Ceylon species is distinguished from *Sterigmatocystis* by its rod-shaped conidia, 3–5 × 1 μ, with rounded ends. As Vuillemin has shown, the apex of the conidiophore of *Gibellula* is not notably inflated, and the resemblance to *Sterigmatocystis* is merely superficial.

In *Gibellula phialobasia* Penz. and Sacc., the structure of the conidiophore is different, according to the figure and description,

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and the fungus appears to be a *Spicaria* or *Verticillium*. The same would appear to apply to *Gibellula eximia* von Höhn., and *G. formosana* Sawada.

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EXPLANATION OF PLATE I.

Fig. 1. *Cordyceps Barnesii*, natural size, from the original painting.
2. *C. gracilis*, natural size.
3. *C. coccinea*. ×2.
4. *C. dipterigena*, typical specimen. ×4.
5. *C. dipterigena*, a variant head. ×8.
6. *C. dipterigena*, abnormal head. ×6.
7. *C. myrmecophila*, natural size, from the Ceylon painting.
8. *C. Blattae*. ×2.
9. *C. unilateralis*. ×4.
10. *C. falcata*. ×2.
11. *C. falcata*. ×2.
12. *C. falcata*, conidial stage. ×4.
13. *C. pruinosa*. ×2.
14. Ascus of *C. Blattae*. ×600.
15. *C. translucens*. ×4.
16. *Hirsutella clavispora*. ×2.
17. *H. citriformis*. ×6.

STUDIES IN ENTOMOGENOUS FUNGI.

(With Plates II, III and 1 Text-fig.)

V. MYRIANGIUM.

By T. Petch, B.A., B.Sc.

The first description of the genus *Myriangium* was published by Berkeley in Hooker's *Lond. Jour. Bot.* iv (1845), p. 72. Berkeley had received specimens from West Australia, and on submitting them to Montagne, he found that the latter had similar specimens from France and Algeria. Consequently the genus was published under joint authorship.

Berkeley's account is as follows:

"A very curious new genus was sent by Mr Drummond amongst the Fungi, allied to *Collema*, but with the outward habit, and in some respects the structure, of a *Dothidea*. One species is identical with a plant gathered by Dr Montagne many years since, without fructification, in the department of the Eastern Pyrenees, on the white mulberry, and has lately been found in Algiers on the *Lentiscus*; the other species has at present been found at the Swan River only.

"*Myriangium* Mont. et Berk.

"Thallus pulvinatus, cartilagineus madore turgescens inaequabilis tuberculatus intus pallescens. Apothecia tuberculiformia primo clausa, tandem aperta plana immarginata. Thalamium (lamina proligera) crassum fuscum multiloculare; singulo loculo ascum unicum fovente, tandem fatiscenti-pulverulentum. Sporidia oblongo-cylindrica octona, octies annulata, annulis interdum quadrate cellulosis, pellucida, ascis sphaericis inclusa.

"1. *Myriangium Duriaei* Mont. et Berk., majus, haemisphaericum, subnitidum. Hab. In Pyr. Or. (Montagne), ad corticem Mori albi; Lentisci in Algeria (Durieu); in Australia in Prov. dicta Swan River (Drummond).

"2. *Myriangium Montagnei* Berk., minus, irregulare, atropurpureum, subtiliter tomentosum. Drumm. n. 262. Hab. Ad corticem in Australia in Prov. dicta Swan River. Drummond.

"The second species resembles extremely *Dothidea examinans* Berk. and Mont.; but not only are the sporidia quite different, the cells containing a single ascus only, but the whole structure of the plant is that of *Collemaceae*.

"The genus bears a certain external resemblance to *Tympanis*, without, however, the least affinity. It is more nearly allied to *Arthonia*, but differs from it in the structure of the thallus and nucleus. It is again allied to *Paulia* Fée (Linn. vol. x, tab. 4), but the fructification is different; and also to *Omphalidium* Mey. and Flotw., in which the asci and sporidia have a very dissimilar form, and the structure of the thallus is quite unlike. Complete figures will shortly be published by Dr Montagne."

In Bory de St Vincent, *Exploration Scientifique d'Algérie*, 1, p. 212 (1846), Montagne gave the following description of *Myriangium Duriaei*.

"Thallus e rimis corticis erumpens, orbiculatus, submonophyllus, minutus, millimetra quatuor diametro attingens rarissimeque superans, plerumque minor, pro ratione crassus, convexus, quandoque et hemisphaericus, rugoso-granulosus, tuber-

culatus, polycoccus, fuscus, intus pallescenti-corneus, ex apotheciis ad varios evolutionis gradus prorsus compositus, et *Collema conglomeratum* referens. Apothecia quam plurima thallum obtegentia, tuberculiformia; tubercula initio capitibus harum spinularum orichalcarum vernacule *camions* dictarum haud absimilia, tandem apice dehiscentia sensimque dilatato-aperta, disco subimmarginato fusco-pulverulento. Thalamium cellulosum, multiloculare, loculis longitrorsum transversimque pluriseriatis, singulo loculo ascum singulum includens. Loculi sphaerici oblongique, $\frac{7}{200}$ millim. diametro aequantes, quorum parietes fere contigui vel $\frac{1}{200}$ millim. vix crassiores ut et totus thallus e cellulis minutissimis compositi sunt. Quisque loculus ascum singulum, ut jam supra dictum fuit, fovet, quo ita repletur ut nullum vix intervallum inter eum et membranulam asci perspici possit. Asci sphaerici eadem cum loculis magnitudine utentes, hyalini, sporidia octona nullo ordine includentes. Sporidia oblonga, utroque fine obtusa et ipsa hyalina, nitore margaritaceo insignia, octies deciesve annulata, annulis quadrate cellulosis, iis *Arthoniarum* haud absimilia."

Montagne stated that he had specimens from the Pyrenees, Algeria, and Australia, and that *Myriangium Montagnei* differed in its purple-black colour and tomentose surface. His figures were drawn from a specimen from the Département Pyrénées Orientales, "Mas de las Abeillas, dans les Albères," but, in contradiction to Berkeley's statement, he gave figures of the spores, showing them as oval or fabaeform. The enlarged figure of a stroma shows close-set, flattened tubercles; that of a vertical section shows two apothecia which have changed colour internally. According to these figures and Montagne's later declaration, the type specimen of *Myriangium Duriaei* is that from Pyrénées Orientales.

Shortly afterwards, another collection of *Myriangium* was sent to Berkeley by Curtis from South Carolina. Berkeley forwarded it to Montagne, who expressed his regret that he had not had this gathering when he published figures of the genus based on the type which he had collected, in 1830, on mulberry near Perpignan. Montagne described this American species as *Myriangium Curtisii* Berk. & Mont., and published an amended generic description, in Cent. VI, No. 70, *Ann. Sci. Nat.*, Sér. 3, XI (1849), p. 245, as follows:

"COLLEMACEAE.

"*Myriangium* Berk. et Montag.

"Char. emend. Thallus orbiculatus, tuberculatus, aut inaequabilis ambitu plicato-striatus, gelatinosus, madore tur-

gescens, atro-fuscus, intus pallescens. Apothecia, imperfecta tuberculiformia immarginata, perfecta vero scutelliformia, a thallo marginata, primo clausa, dein aperta, thalamium includentia crassum, concolor, fuscum, multiloculare, loculo singulo ascum singulum fovente, tandem fatiscenti-pulverulentum. Sporidia oblonga, octona, octies annulata, annulis quadrate cellulosis, pellucida, ascis ex ovoideo sphaericis inclusa. Myriangium Berk. et Montag., in Lond. Journ. of Bot., febr. 1845, p. 72, et Fl. d'Alg. 1, p. 213, t. 19, fig. 2.

"*Myriangium Curtisii* Berk. et Montag. mss.; thallo plano orbiculari inaequabili ambitu radiato-plicato atro-fusco, apotheciis scutelliformibus margine elevato integerrimo instructis, disco subconcolori. Hab. Ad ramos fruticum Carolinae inferioris a Rev. M. A. Curtis, cui libente animo dicamus, lectum.

"Desc. Thallus orbiculatus, in plagulas parvulas 3 ad 5 millim. diametro aequantes expansus, cartilagineus, fragilis, atro-fuscus, centro inaequabilis, ambitu tenuiter breviterque radioso-plicatus, intus sordide olivasceus, cortici arcte applicatus. Apothecia pro ratione ampla, majora millimetrum lata, sessilia, haud adnata, elevato-marginata, scutelliformia, concaviuscula, margine thallode integerrimo instructa, disco subconcolori. Thalamium crassum, tertiam millimetri partem adaequans, cellulosum, multiloculare, loculis multiseriatis, singulo ascum unicum fovente. Asci obovato-oblongi, 0·04 millim. longi, 0.03 millim. crassi hyalini, sporidia suboctona (immatura) includentes."

It would appear from Montagne's remarks that he considered this species distinct from *M. Duriaei*, because of the shape of the apothecia. "Elle en est en effet le représentant le plus parfait, puisque ses apothécies sont en grande partie libres en dessous et hautement marginées par le thalle."

In *Syll. Crypt.* (1856), pp. 380, 381, Montagne repeated the foregoing generic description with verbal emendations. He enumerated two species only, viz. *M. Curtisii* and *M. Duriaei*. Following "disco subconcolori" of his previous description of *M. Curtisii*, he added, "ascis obovato-oblongis, sporas 8 (immaturas) foventibus," and omitted the details of the second paragraph. *M. Duriaei* was described as, "Thallo e cortice erumpente, orbiculato, convexo-hemisphaerico rugoso-granuloso, polycocco, ambitu haud effigurato; ascis sphaericis, sporas 8 oblongas tandem quadrate cellulosas includentibus. Hab. Ad corticem *Mori*, in Pyrenaeis orientalibus, primus (1830) Ipse legi; dein in Algeria, ad corticem Lentisci: Durieu; apud Melodunum: Roussel; tandem in Australia, cum *Myriangio Montagnei* Berk., l.l.c.c.; Drummond."

Berkeley, in referring to Myriangium in his *Introduction to*

Cryptogamic Botany (1857), p. 408, stated, "In the two original species the disc is mostly veiled; but in *M. Curtisii* Berk. and Mont., which is by far the finest, it is as open as in any *Collema* or *Leptogium*."

In *Ann. Sci. Nat.* Sér. 4, III (1855), p. 146, Nylander listed *Myriangium Duriaei* from Chili. He described it as "Thallus cum apotheciis confluens in pulvinulos piceo-atros opacos nodulosos, depressiusculos, intus fere concolores obscuros; thecae sphaericae vel ellipsoideae, sporae 8-nae oblongae, non coloratae, longitudine 0·020–25 millim., crassitie 0·010–12 millim., transversim tenuiter 5-divisae, addita saepius divisione longitudinali plurimas transversas percurrente, omnibus vero his septulis sat irregulariter varieque dispositis. Protoplasma thecis inclusum iodo vinose fulvescens. Ad cortices arborum, saepe supra thallum aliorum lichenum crustaceorum. Genus paradoxum, Arthoniis in serie Lichenaceorum potissime affinitatem quandam offerens."

In *Prodromus Lichenographiae Galliae et Algeriae* (1856), Nylander included *Myriangium Duriaei* with the note, "Plantula omnino paradoxa, nec inter lichenes locum suum haud parum dubium servans nisi ob virescentiam obscuram sectionis thalli. Ad corticem arborum, praesertim ulmorum, ad ramos potissime, saepeque ibi supra thallum lichenum crustaceorum, in Gallia et in Algeria, verisimiliter non rarum, sed facile praetervisum."

In *Synopsis methodica Lichenum* (1858), Nylander gave the following account of the family *Myriangiacei*:

"FAMILIA II—MYRIANGIACEI.

"Thallus coloris obscuri, nigricantis parvus, noduloso-pulvinatus, texturae cellulosae aequalis (strata nulla exhibentis), sectione opacus, obscurus, friabilis. Apothecia formae peculiaris sublecanorinae, thalamio similiter celluloso ac thallo, solum illo discolore; thecae in loculis thalamii sphaeroideis aut sphaeroideo-ellipsoideis aut late ovoideis inclusae sporis 8-nis oblongis irregulariter septatis vel fere murali-divisis incoloribus, in thalamio absque ordine farctae, juniores supra pariete crasso (ut in Arthoniis).

"Momentis plurimis secedunt plantulae huc pertinentes et a Collemaceis et a Lichenaceis, his tamen majorem praebent affinitatem textura anatomica, ad illos quodammodo vergunt facie externa. Maxime singulare iis adest thalamium cellulosum cavitatibus theciferis excavatum rotundatis (inordinate seriebus 2–5 superpositis vel conferte inspersis), ut lamina tenui visum quasi cribrosum adpareat.

"Species modo binae cognitae (vel tres?) [footnote—*Myri-*

angium inconspicuum Babingt., L. New Zeal. p. 46, t. 128 est *Arthonia lurida* Ach., cur parum commune habet cum genere Myriangio.—*Myr. Montagnei* Berk. a me non visum], quarum altera quoque in Europa viget. Sunt corticolae, saepeque supra thallos Lichenaceorum occurrunt.

"TRIB. I.—MYRIANGIEI.

"Unica quum sit hujus familiae tribus nullas addendas habemus notas iis, quae jam pro familia afferuntur.

"1. *Myriangium* Mnt. et Berk.

"Nec, ob eandem rationem, hic necesse est, ut definitioni familiae jam datae aliquid adjiciatur; quare ad definitionem praecedentem relegamus lectorem. Spermogonia adhuc ignota.

"1. *M. Duriaei* Mnt. et Berk. in Hook. Jour. Bot. 1845, p. 73, DR. Alger. p. 214, f. 2*, Desmaz. Cr. Fr., éd. 2, 1598, Nyl. Addit. Cr. Chil. in Ann. sci. nat., 4, III, p. 146; *Collema glomerulosum* Tayl. in Mack. Hibern. 2, p. 108 (non Ach.).

"Thallus niger opacus parvus (latit. 2–4 millim., altit., 0·5–0·6 millim.), tuberculato-glomeratus vel noduloso-confluens, saepe depresso-pulvinatus, glomerulis his sparsis; apothecia in nodulorum apice sita concolora, minuta, parum vel vix impressa; sporae oblongae vel oblongo-ovoideae varie septatae, longit. 0·020–36 millim., crassit. 0·009–0·016 millim.

"Ad cortices arborum, saepe supra thallum aliorum Lichenum crustaceorum vulgarium in Europa ad fraxinos, ulmos (praesertim ad ramos), etc.; vix nisi in Gallia et Hibernia adhuc observatum, sed verisimiliter late distributum, nec nimis rarum. Etiam in Algeria, ad lentiscos. In America (e Mexico in Chili) quoque et in Australia (ex hb. Hook.).

"Si nomen glomerulosum Tayl. purum fuisset, id speciei huic conservassem, nam evidenter prioritatem habet; utpote jam receptum et cognitissimum M. Duriaei forte nomen retinendum. Notis jam datis vix aliquid majoris momenti addendum. Protoplasma thecarum iodo vinose fulvescens.

"2. *M. Curtisii* Mont. et Berk. in Ann. sci. nat., 3, XI, p. 245, Mnt. Syll. p. 381. Thallus niger vel fusco-niger opacus parvus (latit. 3–5 millim.), inaequalis vel granuloso-inaequalis, depresso-pulvinatus, ambitu interdum sublobatulo-effiguratus; apothecia concolora vel subconcolora plana opaca (epithecium extus subsimile epithallo), saepe subrugulosa, majora (latit. circa 1 millim.), lecanorina, margine thallino integro cincta: sporae oblongae fere murali-divisae, longit. circa 0·018 millim., crass. 0·008 millim. Ad ramos fruticum in Carolina inferiore, ex auctt. citatis et speciminibus in herbariis variis.

"Facile dignotum a praecedente mox forma apotheciorum

externa. Thecae seriebus pluribus inordinatis superpositis thalamium lamina tenui visum crebre cribrosum reddit; hae minores et crebriores quam in praecedente.

"Non vidi *Myriangium Montagnei* Berk. in Hook. Journ. Bot. 1845, p. 73, nimis breviter verbis sequentibus indigitatum: 'minus (quam *M. Duriaei* B. et M.) irregulare atropurpureum subtiliter tomentosum. Drumm. n. 262. Hab., ad corticem in Australia, in provincia dicta Swan River.'"

In 1886, Millardet published a paper "Des Genres *Atichia, Myriangium, Naetrocymbe.* Mémoire pour servir à l'histoire des Collemacées" (*Mém. Soc. Sci. Nat. Strasbourg*, VI). In *Myriangium*, he had examined European specimens from Cherbourg and from Italy, and American specimens, Lindig 2583, from New Granada. He found that in the American specimens the cortical zone consisted of long narrow cells, with their greatest diameter perpendicular to the surface, but in the European plant this cortical zone was absent, or scarcely distinct: in the American examples, the spores measured 24–32 × 9–15 μ, and in the Italian examples, 25·7–35 × 9·6–14 μ. Of his figures, Nos. 23, 24, 27, 28, and 29 are from the American specimens, and 25 and 26 from the Italian examples. Some of these figures have been reproduced in Engler-Prantl, lettered *A* to *E*; 25 = Engler-Prantl, *C*; 23, 24, 27, 29 are *A*, *B*, *D*, *E*.

Millardet noted that the apothecia of the European form were poorly developed in comparison with the American, but he regarded the two as identical. He also noted that here and there on the surface, and more rarely in the interior, there was sometimes a green coloration due to a *Protococcus*, but in his summing up he stated that *Myriangium* does not possess chlorophyll at any stage.

The specimen, Lindig 2583, was issued as *Myriangium Curtisii*. Millardet did not cite this specific name, nor venture into the question of nomenclature, but his results would make *M. Curtisii* a synonym of *M. Duriaei*, presuming that the specimens had been correctly named.

In *Flora* (1869), p. 298, Nylander pointed out that Millardet's figures Nos. 23 and 24 belonged to *Myriangium Curtisii*, according to the naming of the specimens.

Tuckerman, in *Genera Lichenum* (1872), p. 141, has the following note on the subject.

"*M. Duriaei* Mont. & Berk., in Fl. Alg., the original species (Pyrenees, Montagne! Mass. Lich. Ital. n. 27! Rabenh. Lich. Eur. n. 635!) has been traced already to Algeria, to Australia, and South America (Brazil, Pabst! Lindig Herb. N. Gran., n. 2583, 2669, 2789!) and, reaching Cuba (Wright!), should be

likely to appear also within our southern boundaries. And the plant (*M. Curtisii* Mont. & Berk.) which does occur here, and extends northward along the coast (Carolina, Curtis, Ravenel; Alabama, T. M. Peters; Massachusetts, C. F. Sprague, H. Willey), though certainly noticeable, at least in its best conditions, for general luxuriance—the larger thallus becoming also effigurate, and the apothecia perhaps more perfectly lecanoroid—is by no means satisfactorily distinguished from the other. The 'striate-plicate' circumference found by Montagne in both his species, and re-affirmed by Massalongo of *M. Duriaei*, may in fact be considered as implying the at length certainly striking, but inconstant lobation of the North American *Myriangium*; and one of the New Granada forms of the older species (Lindig n. 2583), as determined by Nylander, is quite as distinctly effigurate as the Carolina plant. [Footnote.—It is, in this connection, observable, that both the species, as defined, are now recognised as European plants;—*M. Duriaei* Millard. in Mém. Soc. Sci. Nat. Strasb., being referred by Dr Nylander (Flora, 1869, p. 298) to *M. Curtisii*.] The apothecia are similar in both, and similarly modified; and the supposed diversity in the thekes (Mont. Syll.) is far from characteristical. And this last remark applies also to the results obtained by Nylander (Syn.) from the specimens before him; neither the thekes of the Carolina plant, nor its spores differing, in a wide view, in any important respect, from those of *M. Duriaei*. [Footnote.—Very commonly roundish-ovoid, or 'ovate-ventricose' (Mass.) and not much exceeding 0·050 mm. in their longest diameter, the thekes of *Myriangium* also occur oblong, or 'obovate-oblong'; and the latter condition was understood by Montagne to be characteristical of his *M. Curtisii*. But this exceptionally elongated state, which I have observed to measure 0·069–92 mm. in length by 0·023–35 mm. in width, is by no means confined to the North American specimens, or even more frequent in them, spores of the Carolina plant averaging 0·025–35 mm. in length by 0·007–11 mm. in width.] The lobulate margin of the North American plant is at length quite free from the substrate, when the underside of the fringe is seen to be entirely similar in all respects, whether of configuration, colour, or smoothness, to the upper; an observation not perhaps wholly without bearing on the question of the affinity of *Myriangium*."

With regard to the foregoing, it must be noted that Tuckerman misinterpreted Nylander's statement in *Flora, loc. cit.* Nylander only pointed out that Millardet's figures 23 and 24 belonged to a specimen which had been identified as *Myriangium Curtisii*. And the statement that the latter species had been

recognised to be European is also in error, for Millardet's figures in question were drawn from an American specimen. This is the specimen which Tuckerman lists under *M. Duriaei* and refers to as one of the new Granada forms of the older species, Lindig, n. 2583. Tuckerman was also unfortunate in conveying the suggestion that Nylander regarded *M. Duriaei* and *M. Curtisii* as identical, for Nylander (*Synopsis*) did not give measurements of the asci, and stated that *M. Curtisii* was easily distinguished from *M. Duriaei* by the shape of the apothecia. Further, although it is true that Montagne (*Sylloge*) gave the asci of *M. Duriaei* as spherical, and those of *M. Curtisii* as oblong-ovate, he did not state that that difference was the distinguishing character between the two species. Reference to Montagne's original description shows that he was especially impressed by the differences in the size and shape of the apothecia, as was evidently perceived by Nylander (cf. Plate II, figs. 1 and 6).

Bornet, in "Recherches sur les gonidies des lichens" (*Ann. Sc. Nat.*, Sér. V, XVII (1873), p. 95), wrote, "Le *Myriangium Duriaei* Berk. et Montg., type de la tribu des Myriangiés, n'est pas compris dans l'énumération précédente, parce qu'il ne contient aucune trace de gonidies, ni dans les pulvinules qui renferment les thèques, ni dans le mycélium souscuticulaire, ce qui semble l'exclure de la classe des Lichens."

In *Synopsis North American Lichens* (1882), p. 261, Tuckerman listed "*Myriangium Duriaei* (Mont. & Berk.) Tuckerman, Gen. Lich., p. 140" with the synonyms "*M. Duriaei* & *M. Curtisii* Mont. & Berk., in Mont. Syll. p. 380; Nyl. Syn. 1, p. 139, t. 4, f. 1–5."

In *Bull. Torrey Bot. Club*, X (1883), p. 76, Ellis and Everhart described *Cenangium asterinosporum* E. & E., which occurred on living branches of *Vaccinium corymbosum*. Specimens were issued in Ellis, *N. A. Fungi*, No. 1279.

In *North American Pyrenomycetes* (1892), Ellis and Everhart published the name of the original species as *Myriangium Durieui*, the name of the collector of the Algerian specimen being Durieu, and gave the following synonymy:

Myriangium Curtisii Mont. & Berk., in Mont. Syll. p. 380.
Pyrenotheca yunnanensis Pat., Bull. Soc. Bot. Fr. p. 155. 1886.
Phymatosphaeria yunnanensis Sacc., Syll. VIII, p. 847.
Cenangium asterinosporum E. & E., in N. A. Fungi, 1279.
? Phymatosphaeria brasiliensis Speg., Fungi Puigg. p. 174.
? Phymatosphaeria abyssinica Pass., Nuovo Giorn. Bot. Ital. VII, p. 118.

Ellis and Everhart added the note:

"The measurements of asci and sporidia are from the Florida specimens; those from more northern localities have the sporidia mostly smaller. The Florida specimens (*M. yunnanensis*) also

differ from those found in the northern States in the absence of any free-margined thalloid effigurate subiculum....We have seen no specimens of *Phymatosphaeria abyssinica* and *P. brasiliensis.*"

With regard to Ellis and Everhart's synonymy, it would appear that the reference of their *Cenangium asterinosporum* to *Myriangium Duriaei* was made by themselves, and that they followed Tuckerman in similarly referring *M. Curtisii.* As for the inclusion of *Phymatosphaeria yunnanensis,* it would seem that Florida specimens had been identified as that species, and that having found that the specimens were *Myriangium Duriaei,* Ellis and Everhart concluded that the two names were synonymous. But I have been unable to find any record of *Phymatosphaeria yunnanensis* in any list of Florida fungi, or to discover who assigned Florida specimens to that species. In the original description, only Yunnan is given as the locality.

Starback, in *Bihang K. Svenska Vetensk.-Akad.* XXV, III, No. 1 (1899), described the "Ascomyceten der ersten Regnellschen Expedition," and dealt with the *Myriangales* on pp. 37–42. He stated that he could find no difference between *Myriangium* and *Phymatosphaeria* Pass., but did not record that he had examined the type specimen of the latter. He examined *Myriangium Duriaei* in Rabenhorst, *Fungi Europaei,* No. 4067; this, however, is an American specimen. In describing a new species, *M. thallicolum* Starb., he referred to *M. yunnanense* (Pat.) and *M. Duriaei* Mont. & Berk., apparently regarding the two latter as distinct species.

In *Hedwigia,* 39 (1900), pp. 97, 98, Rehm gave the following synonymy:

Myriangium Duriaei Mont. & Berk., Hook. Bot. Journ. p. 73. 1845.
Syn. Phymatosphaeria abyssinica Pass., f. Abyss. p. 188, t. v, f. 11. Cfr. Sacc., Syll. 1, p. 72.
Phymatosphaeria yunnanensis Pat., Bull. Soc. Bot. Fr. p. 156, 1886, sub *Pyrenotheca*; Sacc., Syll. Discom. p. 847.
Myriangium Curtisii Mont. & Berk., Ann. Sci. Nat. 3, XI, p. 245.
Cenangium asterinosporum E. & E., Bull. Torr. Bot. Club, X, p. 76.
Collema glomerulosum Tayl., Fl. Hibern. pt 2, p. 108 *sec.* Mudd, Man. Brit. lich. p. 50, Pl. I, f. 10, sub *M. Duriaei.* Cfr. Nyl. Syn. lich. 139, t. 4, f. 1–5 egregie.

Rehm did not state on what evidence this synonymy was based. It was cited by von Höhnel on the specimens of *M. Duriaei* from Java distributed by him. In Fragmente, No. 244, von Höhnel wrote that *Pyrenotheca yunnanensis* Pat. and *Phymatosphaeria abyssinica* Pass. were, "wie bereits bekannt," synonymous with *Myriangium Duriaei* Mont. and Berk., and referred his readers to Rehm, *loc. cit.*

Structure.

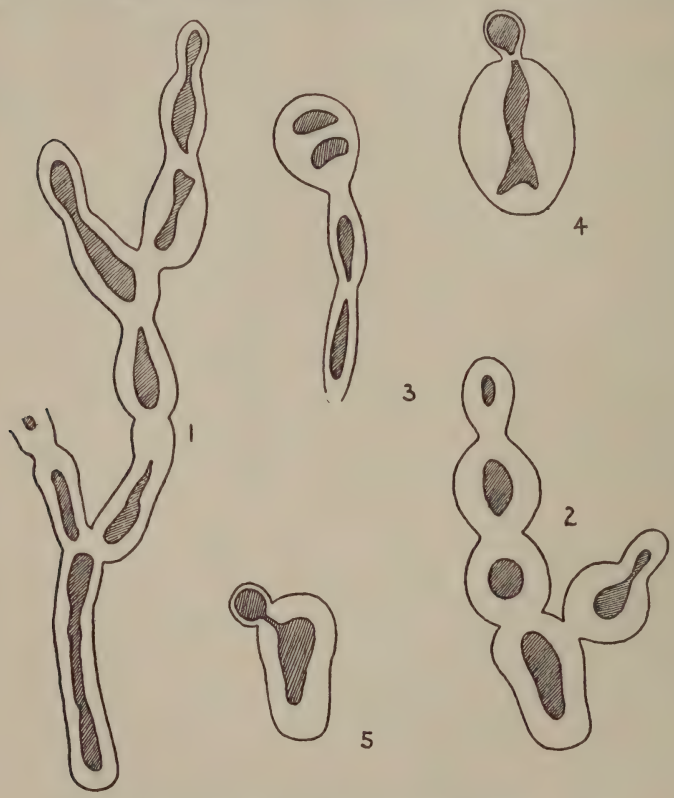
Berkeley, in the original generic description of *Myriangium* (1845), stated that the stroma was "cartilagineus madore turgescens," and Montagne, in the amended generic description published in 1849, described it as "gelatinosus madore turgescens." Taylor, however, in recording *Myriangium Duriaei* from Ireland (1836) under the mistaken identification, *Collema glomerulosum* Ach., noted that "it alters very little its hue or size by being wet"; and Wilson (1892) stated with regard to *Myriangium dolichosporum* (= *M. Montagnei*) that it did not "appreciably increase in size when moistened as the *Collemacei* do." In fact, in none of the species of *Myriangium* examined during the preparation of this account is the stroma gelatinous, nor does it alter its size or shape on being wetted.

In the species of *Myriangium* which are parasitic on scale insects, the stroma consists of a basal disc, either continuous or lobed, from which arise numerous erect processes (Plate II, figs. 1–10; Plate III). In European forms of *M. Duriaei*, the basal disc is usually well developed and flattened-pulvinate, but in tropical examples of the same species it may be merely a thin film. The processes may be pulvinate, or turbinate, or nail-shaped, *i.e.* with a broad circular top on a narrow stem-like base. In some examples the fertile stroma lacks processes and is simply pulvinate (Plate III, fig. 3). All these forms may occur in the same species, and it does not appear possible to establish species on the shape either of the processes or of the basal stroma only.

The stroma is composed of thick-walled hyphae which run more or less radially from the centre in the basal portion, and vertically upwards in the processes. In the young processes of *M. Duriaei*, the internal tissue is often plainly vertically fibrillose, but this character may be subsequently obliterated by the intermingling of the branches of the hyphae and their fusion into a compact tissue. The hyphae, however, are not so strongly contorted, nor so firmly united to one another, as in the stromata of *Hypocrella* or in sclerotia, and sections readily separate into short lengths, or joints, of hyphae under pressure, while many specimens show a fibrillose structure when broken.

The hyphae (Text-fig. 1) are from 2·5–6 μ diameter in *Myriangium Duriaei* and 1·5–5 μ in *M. Curtisii*. They are slightly irregular and very thick-walled, a hypha 6 μ diameter sometimes having an irregular discontinuous lumen only 1·5 μ diameter. Owing to the strong thickening of the walls, septa are not evident, but their position is usually indicated by a constriction of the wall, and the hyphae readily break up into joints 10–12 μ long. The hyphae branch dichotomously (Text-fig. 1),

and ultimately pass into similarly branching chains of thick-walled cells (Text-fig. 2), either spherical, 4–14 μ diameter, or oval, 10–14 × 9–10 μ (*M. Duriaei*), or 7–11 × 5–8 μ (*M. Curtisii*). Both forms of hyphae occur in all parts of the stroma, but the spherical cells are the more numerous towards the exterior. The lumen of the spherical cell is usually very small, 1–3 μ. In the upper part of the stroma, however, the cell wall in many cases is not so strongly thickened, and may be only 1–2 μ thick. In



Hyphae from the stroma of *Myriangium Duriaei*. × 1000.

M. Thwaitesii nearly all the cells of the stroma are oval or globose.

The hyphae increase in length by apical or lateral growth from the terminal cell (Figs. 4, 5). In some cases, the new cell is thin-walled at first; in others it appears to be thick-walled from the beginning. The contents of the terminal two or three cells often remain continuous until the apical cell is well developed. In some instances, a cluster of spherical cells appears

to be borne at the apex of an elongated hypha, but as all the cells of the stroma naturally adhere to one another, this appearance is probably fictitious. A large number of the terminal cells have their contents divided transversely into two semi-oval masses, separated by a thick wall (Fig. 3), but it has not been possible to trace any further division of these into two distinct cells.

The stroma is moderately hard, but in general it easily breaks transversely, and hence the processes and apothecia are often lacking in herbarium specimens. This transverse fragility is perhaps to be associated with the readiness with which the hyphae separate into joints. The stromata of different species, however, differ in this respect, and while sections of *M. Duriaei* break up under the knife, the stroma of *M. Montagnei* is of a cheesy texture and readily furnishes continuous sections. In section, the stroma appears parenchymatous, being composed of narrow, irregular, elongated cells (the long segments of the hyphae), and angular, more or less isodiametric cells (the spherical or oval segments of the hyphae). The exterior layers may consist of polyhedral cells, like those in the interior, or of subrectangular cells, situated with their longer axes perpendicular to the surface. Millardet noted that the latter form of cortical layer was better developed in South American examples of *M. Duriaei* than in European examples. I have, however, examined British specimens of that species in which the cells at the exterior of the stroma were more or less rectangular, and showed a radial arrangement to a depth of 75 μ from the surface.

Berkeley and Montagne considered *M. Duriaei* a lichen. In forming that opinion, they may perhaps have been influenced by the internal colour of the stroma of that species, which, except in old examples, is distinctly green. The green coloration, however, is not due to an algal constituent of the stroma, but to a granular green deposit between the hyphae. In general, this deposit is a thin film, but in places it may be up to 6 μ thick; it does not exhibit any definite structure. Chlor-zinc iodide stains these intercellular masses deep brown, and they assume a brown tint with eosin; with gentian violet they stain deeply and appear black. When the stromata are crushed in alcohol and the mixture heated, a feebly greenish extract is obtained, but this does not give any reactions for chlorophyll. These results agree with those of most of the previous workers on *Myriangium*. The green coloration is not due to an alga, and the stroma does not contain chlorophyll or gonidia. It is frequently possible to find algae associated with the stromata of *Myriangium*, usually in groups of four or more cells, but these

are purely external and their presence is accidental. In *M. Curtisii* and *M. Montagnei*, the stroma is pale brown or yellow-brown internally: in *M. Thwaitesii*, it is white, or almost white, owing to the deficiency of colouring matter except at the exterior. In the latter, the intercellular substance stains yellow-brown with chlor-zinc iodide, and pink with eosin.

The well-known figure of the longitudinal section of the stroma of *M. Duriaei*, published by Millardet and reproduced in Engler-Prantl, *Natürlichen Pflanzenfamilien*, I, i, p. 320, appears to show a parenchymatous structure, composed of cells having thin walls. That interpretation, however, is not correct. The apparently dark cell walls seen in a section are the lines of the green substance between the cells, or segments of the hyphae. The actual cell wall is very thick and the lumen of the cell is small. In many of the cells, especially towards the base of the stroma, there is a small bright spot, about 2 μ diameter, which at first sight resembles a pore in the cell wall; but, on staining the section, it is found that that is the cell lumen, the wall of the cell being thickened to such an extent that the cell is almost solid. A careful examination of Millardet's figure will reveal these minute lumina in some of the cells towards the base. The structure, however, is the same throughout, though the walls of the cells in the upper part of the stroma are usually not so strongly thickened as those of the cells at the base.

The shape of the cells at the exterior of the stroma has already been referred to. These become blackened or browned and form a black cortex. As a rule, this cortex is thin, but in some American examples of *M. Duriaei* it attains a depth of 0·1 mm. The cells of the cortex are more firmly united to one another than those in the interior of the stroma.

When old, the internal colour of the stroma may change. In *M. Duriaei* it becomes purple-brown or purple-black. At the same time the internal tissue becomes friable.

The stromata of the species of *Myriangium* which are parasitic on scale insects are sclerotioid, the thick-walled hyphae being rather feebly united to one another except in the cortex. With chlor-zinc iodide, the cell walls are scarcely stained, but the cell contents and the intercellular substance are stained deep brown. There is no cellulose reaction. Eosin stains the cell contents pink, but the cell wall is not stained. Sudan III in glycerine does not stain the cell wall, but colours the contents and the intercellular substance red-brown. Gentian violet stains the cell wall violet-blue, the intercellular substance becoming almost black.

In the stroma of *M. Pritzelianum*, which is parasitic on plants, the cell walls are not exceptionally thickened, and the cells of

the pseudoparenchyma are all of the same general shape. The stroma is red-brown internally, turning black from the base upwards, the tissue round the asci remaining red-brown.

The fructifications of *Myriangium* are formed at the apices of the processes (Plate III). They have been generally known as apothecia, but their development is scarcely that of a true apothecium and in many instances nothing resembling an apothecium is produced. At a certain stage of development, the surface of the apex of the apothecial process may weather away. The cortex becomes minutely lacunose, or appears matted-tomentose owing to the disappearance of minute particles here and there. This disintegration occurs on no definite plan; it may begin at the margin or at any point on the upper surface, and there does not appear to be any definite abscission layer beneath the cortex which weathers off. In some instances, the tissue separates more or less in scales at the limit of the ascigerous zone; in other cases, the initial cracks penetrate into the ascigerous region; while, perhaps more generally, the initial weathering of the surface layers does not extend to that region. When this disintegration is completed, a cup-shaped depression (Plate II, fig. 4) is left at the apex of the process. The margin of the cup is usually irregular, and the disc is parenchymatous, like the tissue which has weathered off. Thus, this dehiscence does not expose a layer of asci; the latter are still embedded in the parenchymatous tissue.

In *M. Duriaei*, the open apothecium is greenish black; this is due to the green colour of the interior and the gradual blackening of the exposed tissue. In *M. Montagnei*, the open apothecium is brown, at least in the larger examples.

The shape of the apothecium is highly variable in the one species. In *M. Duriaei*, it is typically cup-shaped, concave with a narrow plicate margin, but it may be convex without a distinct margin (Plate II, fig. 3). In *M. Montagnei*, it may be cup-shaped, concave with a stout rounded margin, or broadly concave with a narrow margin, or broadly convex without a differentiated margin (Plate II, figs. 8, 9, 10). Naturally, in this connection one thinks of the smaller Pezizas, which may be concave at first or in dry weather, but become convex in wet weather or through continued growth of the hymenial layer. But the apothecia of *Myriangium* do not notably change their shape with weather conditions, nor does there appear to be any further growth of the disc after the surface has disintegrated. The different forms of the apothecium appear to be due merely to the different sizes attained by the apothecial processes before the upper layer disintegrates, and to the extent of this disintegration over the apex.

In many cases, however, open apothecia are not formed. Asci are produced within the closed processes, and the stroma then decays, its internal tissue changing colour and the cortex breaking up generally. In British examples of *M. Duriaei*, the formation of open apothecia appears to be the rule. On the other hand, open cup-shaped apothecia are practically lacking in tropical examples of that species, but the closed processes contain mature asci. Specimens of the same species from Florida usually resemble the tropical forms in that respect, but some gatherings from that country include open cup-shaped apothecia, similar to those of the British examples.

It is remarkable that there is no definite relation between the formation of apothecia and the development of the asci. The British examples which bear open apothecia may not contain any asci, while tropical examples which do not bear open apothecia contain mature asci in the closed processes. In a stroma of *M. Curtisii*, a large, widely-open apothecium, several millimetres in diameter, was quite sterile, while an adjacent closed process contained asci. It is not possible to determine with certainty by mere inspection whether a given stroma is fertile or not.

Myriangium Pritzelianum, which is parasitic on plants, apparently does not produce open apothecia, judging from the available specimens.

It would appear from the foregoing that the apothecium is not a constant or necessary character of *Myriangium*. It might even be regarded as an accidental feature, dependent upon the manner in which the stroma begins to decay. The stroma may produce asci in its processes and decay as a whole without the formation of open apothecia. It might be suggested that the difference between the temperate and tropical examples is dependent on a more rapid development and decay of the stroma in the latter. In the temperate examples of *M. Duriaei*, the processes are usually longer, and disintegration of the cortex takes place at first over a limited area, *i.e.* the apices of the processes, the remainder of the stroma retaining a glabrous surface: in tropical examples, the processes do not develop to such an extent before ascus formation occurs, and the whole surface of the stroma soon becomes dull and pulverulent.

The asci (Plate II, figs. 11–13) are embedded singly in the parenchymatous tissue. They are usually elliptic or spherical, sometimes with a small conical projection at the base, but in *M. Thwaitesii* they are clavate or pyriform, with a distinct foot (Plate II, fig. 18). The individual asci are separated from one another by a layer of parenchymatous tissue which may be only 4 μ broad, but is usually 16 μ or more. The parenchymatous

tissue which encloses an ascus is more compact and firmly fused together than that elsewhere and forms a kind of sheath, but this would appear to be due to the pressure of the developing ascus; there does not appear to be any "ascogenous cell" in which the ascus is developed. In *M. Duriaei*, the asci occur irregularly scattered through the parenchyma in a cup-shaped, or globose, region which may descend almost to the base of the process. In *M. Montagnei* and in the available specimens of *M. Curtisii*, they occur usually in a few layers in a lenticular or laterally oval zone, which becomes a narrow zone parallel to the surface in widely-open apothecia. In general, this ascigerous zone is paler than the surrounding parenchyma.

The asci vary considerably in size, and this variation is not necessarily correlated with the size of the spores. This is especially marked in *M. Duriaei*. In that species, some of the asci are spherical and the spores almost completely fill the ascus; others are elliptical, and double the size of the former, but their spores are confined to the lower part of the ascus, where they form a spherical or elliptical mass, which may be only slightly larger than the mass of spores in the spherical ascus (Plate II, figs. 11, 12, 13). It is not easy to determine the limits of the wall of the ascus, but measurements on broken asci show that the actual wall is comparatively thin, varying from 1 to 3 μ. The spores are embedded, in no particular order, in a small quantity of protoplasm and form a globular mass, while the space between the spore cluster and the wall of the ascus is filled by a homogeneous, hyaline substance of rather firm consistency, which, when the ascus is broken under pressure, sometimes emerges in a continuous sheet. The cluster of spores is contained in a cavity in this plasma; there is no second wall round them. With iodine, the spore cluster stains yellow-brown, but the ascus wall and the hyaline plasma do not stain. In one instance, in a section of *M. Duriaei* which had been subjected to pressure, the hyaline plasma had emerged from the broken ascus in a cylindrical column, containing the spores in a row and resembling a cylindrical ascus, the resemblance being increased by the prolongation of the spore plasm into the apex of the hyaline plasma (Plate I, fig. 14). An identical prolongation has been observed in a case in which the whole of the contents of an elliptic ascus had been extruded, but in this latter instance the hyaline plasma retained its elliptic form, and the spores were situated towards one end in the normal irregular cluster. It is not uncommon to find, in sections disintegrated by pressure, the contents of an ascus, retaining their original shape, but destitute of the ascus wall, or with the wall collapsed at the base of the mass; or asci from which the spores have been extruded, but to which the

hyaline plasma is still attached (Plate II, fig. 20). In the latter case, the hyaline plasma is usually oval or tongue-shaped, but it may be more or less cylindric. As a rule, no cavity is observable in the hyaline plasma after the spores have escaped; in some cases, however, a small quantity of the excess spore-plasm may remain embedded in it.

The cylindrical ascus-like formation would appear to be uncommon. It would seem probable, however, that Tuckerman's elongated asci were of this nature. Its occurrence cannot be a universal phenomenon, since the spherical asci, in general, contain only a small amount of this hyaline plasma.

In Engler-Prantl, *Pflanzenfamilien*, 1, i, p. 320, it is stated that the asci dehisce in consequence of the swelling of the inner layer of the ascus wall (der innern Membranschicht). Presumably this "inner layer" is the substance referred to above as hyaline plasma. It appears to be free from the ascus wall, though no line of separation can be detected in the unbroken ascus. It is possible that dehiscence of the ascus is effected in the manner indicated. But no observations have been made which would indicate that the spherical asci expand into elliptic asci owing to the swelling of the hyaline plasma. Immature asci may be either spherical or elliptic, and a comparison of immature and mature asci, *i.e.* those in which the spores are not yet formed and those in which they are fully developed, suggests that the space occupied by the hyaline plasma diminishes as the spores develop.

It would appear that the spores can only be liberated as the asci are exposed by the disintegration of the parenchymatous tissue. This occurs from above downwards in the open apothecia, but the stroma decays as a whole when the apothecia are not developed. In *M. Duriaei*, the parenchymatous tissue of the open apothecium gradually darkens from above downwards.

The spores (Plate II, figs. 15, 16, 17, 19) are muriform, with regular transverse septa, and longitudinal or oblique septa in some or all of the transverse loculi. At the lower end of the spore the septa are usually oblique. The longitudinal septa are often tardily developed, and hence in some cases the spores have been described as transversely septate only. Before septation, or before the formation of the longitudinal septa, the spores of *M. Duriaei* may be filled with close-set spherical globules. The wall of the spore is thin at first, but becomes thicker as the spore matures.

The colour of the ascospores is greenish hyaline. Brown ascospores have been observed in *M. Duriaei* and *M. Montagnei*, and in one instance in the former species an unopened ascus was seen, the wall of which, and the included spores, were brown.

It would appear that these had remained adherent to the decaying parenchymatous tissue of the disc of the apothecium, and had shared in the colour change of the parenchyma.

Since the foregoing account was written, Mr L. E. Miles has published a description of a new species of *Myriangium*, *M. tuberculans*, in *Mycologia*, XIV, pp. 77–80. His interpretation of the structure of the ascus of *Myriangium* differs from that outlined above, and may be quoted verbatim.

"Each locule is lined with a thick, hyaline sheath, inside which occurs a single ascus. When the stroma is crushed and examined under the microscope, this sheath easily separates from the tissue of the stroma and remains about the ascus, giving the appearance of being merely a very thick ascus wall. If the sheath becomes ruptured, however, the ascus immediately expands, chiefly in a longitudinal direction, often to two or two and one half times its original length, becoming oblong, broadly spindle-form, or ovate with blunt rounded ends, while the ruptured locule sheath collapses about its base. The ascus wall is quite thin as compared with this sheath, except at the apical end, where it is heavily thickened. There is no apical pore and the method of spore discharge has not been observed. Since the locules are indehiscent, and the pore at the apex of the ascus is absent, this probably is brought about by the irregular rupture of the ascus wall."

It will be seen that what I have regarded as the ascus is considered by Miles to be a sheath, while the hyaline plasma is regarded by him as the true ascus wall. In other words, *Myriangium* has ascigerous cells, each containing a single ascus which completely fills the cell. Against this view may be urged (1) the shape of the "ascigerous cell" in *M. Thwaitesii*, (2) the varying shapes assumed by the "ascus" on extrusion from the "ascigerous cell," and (3) the absence of an interior wall and the non-collapse of the "ascus" after the spores have escaped from it. It would appear, however, that the point can be definitely settled only by a study of the development of the structure in question.

Systematic.

As already indicated, species of *Myriangium* have been described as *Phymatosphaeria*, *Pyrenotheca*, and *Cenangium*. To these generic names von Höhnel has added *Diplotheca*. *Phymatosphaeria* Pass., *Pyrenotheca* Pat., and *Diplotheca* Starb. are now regarded as synonymous with *Myriangium* Mont. and Berk., though evidence as regards the first of these appears to be lacking.

The species now admitted as *Myriangium* by von Höhnel and others are as follows:

(1) Myriangium Duriaei Mont. & Berk., Lond. Journ. Bot. IV, p. 74. 1845.
(2) M. Montagnei Berk., loc. cit. supra.
(3) M. Curtisii Berk. & Mont., Ann. Sci. Nat., Sér. 3, XI, p. 245. 1849.
(4) Phymatosphaeria brasiliensis Speg., Fungi Puigg. p. 174. 1889.
(5) Myriangium dolichosporum Wilson, Proc. Roy. Soc. Victoria, V, p. 160. 1892.
(6) M. argentinum (Speg.) Sacc. & Syd., Syll. Fung. XVI, p. 800; Phymatosphaera argentina Speg., Fungi Argentini novi v. crit. p. 299. 1899.
(7) M. thallicolum Starb., Bih. K. Svensk. Vet.-Akad. Handl. XXV, p. 41. 1899.
(8) M. Pritzelianum P. Henn., F. Austral. Occid., Hedwigia, XL, p. 353. 1901.
(9) M. Acaciae McAlp., Proc. Linn. Soc. New South Wales, XXIX, p. 124. 1904.
(10) M. Bambusae Rick, Broteria, V, p. 39. 1906.
(11) M. Tunae (Spreng.) v. H., Fragmente, XIII Mitt. p. 78; Sphaeria Tunae Spreng., Vet. Akad. Handl. p. 49, 1820; Diplotheca Uleana P. Henn., Hedwigia, XXXVII, p. 205. 1898.
(12) M. Rhipsalidis (P. Henn.) v. H., Fragmente, VII Mitt. p. 60; Diplotheca Rhipsalidis P. Henn., Hedwigia, XXXVII, p. 206. 1898.
(13) M. floridanum (Ell. & Galw.) Rehm apud v. Höhnel, Fragmente, VI Mitt. p. 80. 1909.
(14) M. curreyoideum (Theiss.) Sacc. & Trott., Syll. Fung. XXII, p. 581; Phymatosphaeria curreyoidea Theiss., Beih. Bot. Centralb. XXVII, Abt. II, p. 402. 1910.
(15) M. philippinense Syd., Ann. Myc. XII, p. 567. 1914.

Of these, *M. Pritzelianum*, and, *fide* von Höhnel, *M. Tunae* and *M. Rhipsalidis* are known to be parasitic on plants. *M. Duriaei*, *M. Montagnei*, *M. Curtisii*, *Phymatosphaeria brasiliensis*, *M. dolichosporum*, *M. Acaciae*, and *M. philippinense* are parasitic on scale insects. Of the remainder nothing definite can be stated concerning the real host, but from the descriptions, *M. curreyoideum* would appear to be parasitic on plants, and *M. thallicolum* and *M. Bambusae* on scale insects. It would appear doubtful whether the two latter are distinct from *M. Duriaei*, but I have not seen specimens.

Von Höhnel instituted a family *Myriangiaceae* (Fragmente VI, p. 78), which he characterised as "Stroma superficial or erumpent, carbonaceous or brightly coloured, not perithecium-like, internally and externally of the same structure, with numerous loculi each containing one ascus." The characters of the genus *Myriangium*, according to von Höhnel, are "Stroma more or less carbonaceous, black; spores muriform, hyaline."

In the species parasitic on scale insects, the mycelium of the fungus permeates the body of the insect, and the stroma is formed over the insect or at the side of it on the host plant. In *M. Pritzelianum*, the mycelium permeates the plant tissues and grows out to form the stroma on the surface of the plant. In this latter species, the larger stromata are attached only in the centre of the base, or along a median line, but the smaller

stromata may be attached over the whole base and they may then appear to have the base embedded in the tissues of the host. In all cases, however, the actual stroma is formed externally. Montagne's description of *M. Duriaei* as erumpent may have been based on a specimen in which the scale insect was concealed in a crack in the cortex.

In none of the species examined by me can the stroma be said to be truly carbonaceous, as for example in the perithecia of *Rosellinia*, etc. The cortical layer is always evidently parenchymatous, and as a rule it is easily cut, though the stroma may break up under the knife, especially when old, because of the friability of the internal tissue.

In the available species parasitic on plants the stroma is merely parenchymatous. In those parasitic on scale insects the stroma is sclerotioid. In the latter case the shape of the hyphae in the young stroma recalls those of *Atichia*.

MYRIANGIUM.

Stroma superficial, parenchymatous or sclerotioid, usually black, simple, pulvinate, or compound and consisting of a basal disc bearing pulvinate, turbinate, or nail-shaped processes. Asci embedded singly in the parenchyma, in the processes when present, irregularly distributed or in more or less definite regions. Spores muriform, hyaline. Processes sometimes disintegrating at the apex, with the consequent formation of cup-shaped or convex apothecia.

Myriangium Duriaei Mont. and Berk., Hooker's *London Jour. Bot.* IV (1845), p. 73, "quoad specimina ex Pyr. Or. et Algeria." Stromata up to 5 mm. diameter, black or purple-black, shining, or dull and subpulverulent; base flattened-pulvinate, or flat and thin, lobed or continuous, generally radially plicate; apothecial tubercles pulvinate, flattened-pulvinate, or turbinate, up to 0·7 mm. high, usually crowded and concealing the base, rarely wanting; internally green, or greenish white, becoming purple or purple-black when old, friable. Open apothecia usually concave, up to 1 mm. diameter, with a narrow, incurved, incised margin, greenish black. Asci globose, 32–50 μ, or elliptical, 35–66 × 28–52 μ, the spores frequently confined to the lower end. Spores oblong-oval, or subfusoid, ends obtuse, straight or curved, usually with seven transverse septa, and one or more longitudinal or oblique septa in each loculus, constricted at the median septum, the upper half the broader, 14–37 × 6–15 μ, frequently with some globose spores, irregularly radially septate, 8–12 μ diameter. *Collema glomerulosum* Tayl., non Ach., in Mackay, *Fl. Hibern.* II, p. 108 (1836);

Cenangium asterinosporum Ell. and Ev., *Bull. Torrey Bot. Club*, x (1883), p. 76; *Pyrenotheca yunnanensis* Pat., *Bull. Soc. Bot. France*, Sér. II, viii (1886), p. 155; *Phymatosphaeria brasiliensis* Speg., *Fungi Puigg.* p. 174 (1889); *Phymatosphaeria argentina* Speg., *Fungi Argentini novi v. crit.* p. 299 (1899); *Myriangium floridanum* (Ell. and Galw.) Rehm apud v. Höhnel, *Fragmente zur Myk.* vi, p. 80 (1909); *Myriangium philippinense* Syd., *Ann. Myc.* xii (1914), p. 567.

In the original description, specimens were cited from France, Algeria, and Australia. The type specimen is consequently that from France, and this was regarded as the type by Montagne. The specimen from Australia is a different species, and is, in fact, identical with *M. Montagnei* Berk. Up to the present, there is no evidence that *M. Duriaei* occurs in the Australian region. The type in Herb. Montagne from Pyrénées Orientales, dated 1829, contains an abundance of specimens; it is the form usually found in temperate climates.

In Mackay, *Flora Hibernica*, ii, p. 108, Taylor recorded this species for Ireland under the erroneous identification *Collema glomerulosum* Ach. He cited specimens from Roughty. Herb. British Museum has Irish specimens marked "On ash, Roughty, Kerry" (with scale insect); "Fl. Hib. Dr Taylor," not localised; "Dunkerrin"; "Carrigaline, Cork, Oct. 1858, J. Wright"; and "Carrigaline river, Cork, 1865, J. C." (with scale); these have not been re-examined microscopically. Herb. Kew has a specimen from Taylor, "on ash trees near Dunkerrin"; this is *M. Duriaei*, but is apparently immature.

British specimens are represented in Herb. Kew by Crombie, *Lich. Brit. Exsicc.*, No. 8; and Herb. British Museum has the same Crombie number, marked "near Penzance, Cornwall, Wm. Curnow"; this has asci globose 48 μ diameter, or elliptic, 46–56 × 36–40 μ, and spores 24–36 × 9–13 μ. Another specimen, in Herb. B. M., is marked "Bene fertiles. On the branches of ash trees, St Levan, Penzance, legit W. Curnow, v, 1874," and includes a scale insect with *Microcera coccophila*; its asci are globose, 32–38 μ, or elliptic, 36–42 × 28–34 μ, with spores, not fully mature, 16–28 × 9–11 μ. A number of other British specimens in Herb. B. M. have not been re-examined microscopically; these include the following: "Trevella Wood, Penzance, W. C. leg. 1864"; scale and *Microcera* present. "Trevella Carne Grove, Penzance, March 28, 1865, W. Curnow." "Treventh Farm, Penzance, W. Curnow leg. 1870." "Castle Hornock, Penzance, Feb. 1870 and Jan. 1871. W. Curnow." "Ash bark. Treveneth near Penzance, Cornwall, March 7, 1871. W. Curnow"; scale present. "On ash in Trevella Wood, Penzance, Dec. 10, 1873. W. Curnow"; scale and *Microcera* present.

"Trevella Carne Grove, Penzance, 1886, *duce* W. Curnow"; scale present. "Ash trees, Trengwainton, Penzance." "Near Penzance"; scale present. "Penzance, ex herb. W. Curnow." "Ash trees, Penzance, H. B. H." "On ash, wood near the Abbey farm." "Ilsham Walk, Torquay, J. M. C." "Ash trees, Shanklin, I. W."; scale present. "Near Ryde, Isle of Wight, A. B."; scale and *Microcera* present. "Brading, I.W. Leg. 1868." "On trunks of trees, Shanklin, Isle of Wight, legit J. M. C., IV, 1873"; scale present. "Cook's Castle, near Shanklin, I.W., H. Piggot." "Danny, W. Mitten" [Danny Park, West Sussex].

During the Autumn Fungus Foray of the British Mycological Society, 1920, specimens were collected in abundance on *Chionaspis salicis* on ash, Horner Woods, near Minehead, Somerset. The record of effete stromata of *M. Duriaei* for Norfolk and Yorkshire in *Trans. British Mycological Society*, 1920, vol. VII, p. 33, proves on further examination of the specimens to have been a mistake.

M. Duriaei in England, as far as the records show, occurs chiefly in the South-Western Counties from Cornwall to the Isle of Wight, and has been found as far east as Sussex. Its distribution coincides with that of *Microcera coccophila* in England, and, like the latter, it has been found only on *Chionaspis salicis*.

Of French specimens, Herb. Kew has one collected by Roussel, "ad ramos excelsos Ulmi, Meloduno [= Melun, near Paris], March 1850," which includes a scale insect. Herb. B. M. has other examples from the same locality, dated March 8th, 1853, and June 4th, 1855. The asci are globose, 40–50 μ, or elliptic, 48–64 × 40–52 μ, and the spores are generally large, 20–30 × 9–14 μ. There are also in Herb. B.M., "C. Roumeguère, Lichens d' Europe, *Myriangium Duriaei* Berk. & Mont., Carcassonne—Aude. Ad ramos excelsos Ulmi, 1869"; "*Myriangium Duriaei* Mont. & Berk. Sur les Frênes à la Mothe St. Heraie, Deux-Sèvres, Richard, 1873," with a scale insect; "*Myriangium Duriaei* Mont. and Berk., sur un jeune Érable entre Valboum et la tour de Marram (?) (Pyr. Or.), Juillet, 1872, Weddell"; "Desmazières 1948," scale present; and "Desmazières 1598, Éd. II, Sér. I."

Italian specimens in Herb. Kew are "Rabenhorst, Lichenes Europaei 635. Ad truncos Lauri a Boboli Florentiae, Jun. 1861, leg. L. Caldesi," scale and *Microcera* present; "Massalongo, Lichenes Exsicc. Italiae, No. 27," scale present; "Trevisan, Lichenotheca Veneta, Ser. I, Fasc. IV (appendix), No. 146. Ad cort. Fraxini Orni circa Bassano, Marostica, Valdagno in prov. Vicetina," scale present. Herb. B.M. has the first of these, and also "Erbar. Critt. Ital. 745. Sull' alloro nel giardino di Boboli a Firenze," which includes a scale insect and *Microcera*. Raben-

horst 635 has asci globose 40 μ, or elliptic 36–56 × 32–36 μ, and spores 15–36 × 8–15 μ; the surface of the stroma is pulverulent, and the open apothecia are up to 0·9 mm. diameter. The specimen in Massalongo 27 examined contained only immature asci, and Trevisan 146 was apparently also immature.

"Maire, Mycotheca Boreali-Africana, No. 45. Sur les troncs de *Laurus nobilis* L. attaqués par le Coccide *Aonidia Lauri* Bouche, Bouzarea près Alger, 28. 2. 1912" is represented in Herb. Kew; the specimen, which is accompanied by a scale insect, bears stromata which are purple-brown or purple-black internally and are therefore old, but apparently they do not contain asci.

Passerini in *Nuovo Giorn. Bot. Ital.* VII, p. 188 (1875), described a fungus from Abyssinia as *Phymatosphaera abyssinica*. Passerini's species has since been regarded as *Myriangium Duriaei* (cf. Ellis and Everhart, Rehm, von Höhnel), but I have not been able to trace any account of a re-examination of the type specimen. His description does not agree with *M. Duriaei* in several details. He stated that the stroma contained spermatia as well as asci, and that the spores measured 10–15 × 3–4 μ. This measurement is smaller than any I have met with in *M. Duriaei*.

Herb. British Museum contains "Rabenhorst-Winter-Pazschke, 4067, *Myriangium Durieui*. Ad corticem Gleditschiae triacanthis, Amer. bor., Fountain Bluff, Jackson County, Ill. May 1894, leg. C. H. Demetrio"; "Ellis and Everhart, Fungi Columbiani, by G. Bartholomew, 1941, *Myriangium Durieui* Mont. and Berk., on *Crataegus*, London, Canada, Nov. 7, 1903, E. Dearness"; "Lichenes Exsiccati, G. K. Merrill, 174, *Myriangium Duriaei* (Mont. and Berk.) Tuck., Sanford, Florida, S. Rapp, 1910," scale present; "143, Decades of N. A. Lichens, prepared by Clara E. Cummings and A. B. Seymour. *Myriangium Duriaei* (Mont. and Berk.) Tuck., on *Nyssa multiflora*, Acto, N. J., Sept. 27, 1893, coll. Prof. H. A. Green," scale present; all of which appear to be correctly named.

In Herb. Kew, one of Curtis's specimens which was not named by Berkeley, No. 218 on *Crataegus Crus-galli*, North Carolina, is *M. Duriaei*, but I was unable to trace the other Curtis's numbers against which Berkeley placed "Collemal" in the MS. list. The Ravenal specimens assigned to *M. Curtisii* in Herb. Kew, viz. "Fungi Americani Exsiccati 332, in cortice *Nyssa*, Aiken, S. C.," and another specimen on the same host from the same locality, are *M. Duriaei*.

Ellis and Everhart in 1883 described *Cenangium asterinosporum*, collected on living branches of *Vaccinium corymbosum*, Newfield, N.J., April 1883. Subsequently, in *North American*

Pyrenomycetes (1892), they referred their fungus to *Myriangium Duriaei*. Specimens, which are accompanied by a scale insect, were issued in Ellis, *North American Fungi*, 1279, of which there are two copies in Herb. Kew. The stromata are greenish internally, with a stout black cortex, 0·1 mm. thick. The asci are globose, 26–32 μ, or oval or pyriform, 32–38 × 20–26 μ. The spores are those of *M. Duriaei*, but small, 16–19 × 7 μ, with some spherical 8 μ diameter. It is undoubtedly *M. Duriaei*. The stromata are on scales which are embedded beneath the outer layers of the bark; hence Ellis and Everhart described the fungus as erumpent.

Through the kindness of Prof. H. S. Fawcett, I have specimens of *M. Duriaei* from Florida on a scale on *Citrus*. These are flat, covered with close-set, pulvinate elevations up to 0·4 mm. diameter. The surface is pulverulent and there is no free margin. The asci are globose, 32–40 μ, or elliptic, 36–48 × 28–32 μ, and the spores measure 14–28 × 8–13 μ. Many spherical spores, 9–10 μ diameter, are present, one ascus having six of its eight spores spherical. Professor Thaxter has kindly sent me two gatherings from West Palm Beach, Florida, in which the stromata are either flattened-pulvinate with nearly sessile apothecia, or have well-developed turbinate apothecia.

Myriangium floridanum (Ell. and Galw.) Rehm was described by von Höhnel from a specimen on *Citrus* from Florida in Herb. Rehm *ex* Herb. Ellis, labelled *Southworthia floridana* Ell. and Galw. The latter name was not published. Professor Thaxter, who has kindly interested himself in the elucidation of this, informs me that there does not appear to be any specimen labelled *Southworthia* in the Ellis Herbarium, but that there is one marked "*M. Duriaei*, on orange, Florida, Miss Southworth," which may be the specimen in question. From his own herbarium Professor Thaxter has sent me a specimen on orange from Florida, which he received from Ellis as *Phymatosphaeria Southworthii* Ell. and Galw.; the latter is the flat form of *Myriangium Duriaei*, with depressed pulvinate tubercles up to 0·8 mm. diam. and 0·5 mm. thick, asci oval, 50–56 × 40–42 μ, or globose, 40–44 μ diam., and spores, 24–32 × 10–14 μ. It would appear probable that all these names refer to the same collection, and that Ellis removed the *Southworthia* label from his herbarium specimen.

Dr C. Spegazzini has kindly submitted his herbarium specimens of *Myriangium* for examination. *Phymatosphaeria brasiliensis* is represented by three collections; 1678 Puiggar., containing flat specimens, with plane apothecia, up to 1 mm. diameter, crowded in patches up to 5 mm.; F. Puigg., No. 333, on branches of orange, La Plata, March 26th, 1889, containing

pulvinate or flattened stromata parasitic on *Lepidosaphes*; 3789, July 20th, 1883, on bark of Laurineae, containing flat specimens; all these are *Myriangium Duriaei*. *Phymatosphaeria argentina*, La Plata, May 1906, contains small flat specimens, again *Myriangium Duriaei*, together with immature *Nectria* (? *Sphaerostilbe*). I was unable to find *Myriangium* stromata in the type of *M. andinum*, Myc. Argent. VI, *An. Mus. Nac. Hist. Nat. Buenos Aires*, XXIII, p. 99 (1912).

Lindig made three gatherings of *Myriangium* in Colombia (Nova Granata), two of which, Nos. 2669 and 2789, were issued as *M. Duriaei*, and the third, No. 2583, as *M. Curtisii*. There are specimens of the three numbers in Herb. Kew, but they are all the same species, viz. *M. Duriaei*. Consequently Millardet's figures all refer to one species. The spores in 2583 measure 16–25 × 7–9 μ; in 2669, 22–37 × 10–13 μ; and in 2789, 22–32 × 9–13 μ. From Professor Thaxter, I have specimens of *M. Duriaei* from Corral, Chili, Dec. 1905.

Specimens of *Myriangium* from Asia are unaccountably absent from British herbaria, the only ones found being an unnamed Ceylon specimen in Herb. Kew sent by Thwaites, and the specimen of *M. Duriaei* from Java distributed by von Höhnel. The latter is parasitised by *Sirosphaera botryosa* Syd.

Patouillard in 1886 described a fungus from Yunnan as *Pyrenotheca yunnanensis*. This was subsequently referred by Ellis and Everhart (?) to *Myriangium Duriaei*. The type in Herb. Paris is scanty, but on macroscopic examination it appears to be *M. Duriaei*, and Dr Patouillard informed me that he thought that the reference was correct.

Several collections of this species have been made in Ceylon. Parkin (p. 33) recorded it on *Chionaspis biclavis* on *Tabernaemontana*, and on *Aspidiotus camelliae* on *Osbeckia*; the former specimens have flat stromata, with slightly elevated processes, and have developed at one side of, or round the scale; the asci are generally elliptic, 40–54 × 32–42 μ, sometimes globose, 34 μ; the spores measure 16–30 × 8–12 μ, with many spherical, or nearly spherical, 12 μ diameter. Other specimens are as follows: on *Aspidiotus aurantii* on mulberry, Peradeniya, August 1907, May 1909, August 1919; on *Chionaspis* (?) on *Thespesia*, Peradeniya, July 1913; on *Chionaspis* on *Gardenia florida*, Peradeniya, November 1921; on *Pithecolobium subcoriaceum* Thw., Hakgala, March 1922.

From Mauritius, I have a specimen on *Aspidiotus* on bamboo, Oct. 9, 1919, which is immature but appears to be *Myriangium Duriaei*.

Myriangium philippinense Syd. (Plate II, fig. 5) was described by Sydow from specimens on leaves of *Eugenia perpallida*, Prov.

Bulucan. I have examined the part of this gathering retained by the Bureau of Science, Manila, S. 259. The fungus occurs with *Microcera Merrillii* Syd., both of them on a scale insect. Only one stroma of the *Myriangium* was present. This overgrew the scale, and consisted of a flat, very thin disc, irregularly circular, 1·2 mm. diameter, continuous, slightly concentrically ridged, which bore in the centre three close-set, pulvinate processes, 0·2–0·3 mm. diameter and 0·2 mm. high. The stroma was black, with a dull surface, and the basal disc was only 20 μ thick. In section the tubercles were greenish black, with a distinct green colour by transmitted light. The specimen was unfortunately immature, and did not contain any asci. The structure, however, is that of *Myriangium Duriaei*, and in general shape it approaches the thin forms observed in gatherings from Ceylon, Florida, and Colombia. Sydow stated that the spores are ovato-oblong, rounded at the ends, with three transverse septa, and longitudinal septa in one to three loculi, 18–24 × 6–8 μ, the upper half generally the broader. The shape and size of the spore agree with *M. Duriaei*, the only difference being the small number of transverse septa, which may be due to immaturity, though the fact that longitudinal septa were present is opposed to that.

Another specimen of *M. Duriaei* from the Philippines was forwarded to me by Mr E. E. Green, on *Mytilaspis* and *Aspidiotus aurantii* on *Hippocratea* sp., coll. C. S. Banks. It is the usual tropical form.

There is considerable variation in the shape and appearance of the stroma in this species. In British examples the surface of the stroma is usually shining, and young specimens have been collected in Ceylon in the same condition. But, in general, the surface of the stroma in tropical examples, and full-grown specimens from subtropical countries is dull and matt, or pulverulent.

The basal stroma is usually pulvinate or flattened-pulvinate. In some Ceylon specimens, however, it forms a thin flat disc, not exceeding 0·1 mm. in thickness, and similar specimens occur in Lindig 2669 and in collections from Florida. It may be lobed and radially plicate, but in the thinner forms it is generally continuous. In the specimens from Horner Woods, Somerset, many of the stromata consist of a central boss, overgrowing the scale, from which radiate three plicate lobes, but this form is not universal throughout that collection. The outer layer of the stroma and the apothecial processes forms a black wall, usually thin, but sometimes attaining a breadth of 0·1 mm., as in Curtis 218. This greater development of the black cortex was noted by Millardet in Lindig 2583.

The apothecial processes (Plate III, fig. 1) in temperate examples are usually turbinate when full-grown, and they then weather at the apex into a concave disc, the open apothecium. As a rule, the mature asci, in such examples, occur only in the open apothecia. In examples from the tropics, the apothecial processes may be pulvinate or flattened-pulvinate, and they contain mature asci before the apical layer has weathered off. Indeed, gatherings from the tropics, as a rule, do not bear any open apothecia, although the spores are mature. In one example from Ceylon, the basal stroma was 0·075–0·1 mm. thick, and the apothecial processes 0·1 mm. high, giving a total thickness not exceeding 0·2 mm.; the asci in the closed processes were nevertheless mature. Again, Lindig 2669 contains similar mature stromata, the total thickness of which is only 0·25 mm. Despite the extreme variation in the shape of the stromata in the different collections cited, it has not been found possible to separate them into different species. In all essential characters, spores, asci, internal colour and structure, they are *M. Duriaei*.

What is believed to be an abnormal form of this species has been collected at Hakgala, Ceylon, on *Lepidosaphes* on *Cinnamomum ovalifolium*. The stromata are up to 2 mm. diameter, more or less circular, up to 0·5 mm. thick, tuberculate, consisting of clusters of tubercles up to 0·5 mm. diameter. At first they are white, and gradually turn black. Most of the stromata are immature, but in some cases the tubercles are crowned with pezizoid discs, 0·5 mm. diameter. Internally the immature stromata are white, with a narrow black peripheral zone. There is a well-defined cortical palisade layer, 24 μ deep, and the interior of the stroma is composed of thick-walled branching hyphae, 3 μ diameter, in segments about 16 μ long, or in spore-like oval joints, 6 $\times$ 2 μ. The mature apothecia are darker internally and may show a greenish tinge. The asci are globose, 28–32 μ, or oval, 36–40 $\times$ 28–32 μ, and the spores, 18–24 $\times$ 8–10 μ. The spores, asci, and the structure of the stroma are exactly those of *M. Duriaei*; and the specimens appear to be a form of *M. Duriaei*, lacking the green colouring matter.

Distribution. Europe—England, Ireland, France, Italy. Africa—Algiers, Mauritius. Asia—Ceylon, Java, Yunnan, Philippines. North America—United States, Canada. South America—Colombia, Chili, Brazil, Argentina. Generally distributed throughout the tropics and extending into the temperate zones, but not yet known from Australia.

Myriangium Curtisii Berk. & Mont., *Ann. Sci. Nat.*, Sér. 3, XI (1849), p. 245. Stromata pulvinate or flattened-pulvinate, up to 8 mm. long, 5 mm. wide, 2·5 mm. high, sometimes crowded

together in large masses, usually with an abrupt sloping margin, rarely with a thin flat margin, surface plicate, margin radially plicate, black, internally pale brown or yellowish brown or almost white, friable. Apothecial tubercles flattened-pulvinate, about 0·2 mm. high, or subturbinate, up to 0·8 mm. high. Apothecia usually sessile on a broad base, occasionally constricted below into a narrow, stalk-like base, up to 2 mm. diameter, black, flat, becoming convex and dark grey with a brownish white zone near the margin. Asci in the open apothecia confined to a zone parallel to the upper surface, globose, 26–28 μ diameter, or elliptic, 32–44 × 21–34 μ. Spores oblong-oval, narrow-oval, or subfusoid, straight or curved, with up to seven transverse septa, constricted at the median septum, and longitudinal or oblique septa in some or all the loculi, 12–28 × 5–11 μ. *Myriangium tuberculans* Miles, Mycologia, XIV, p. 80 (1922).

This species was founded on a specimen collected by Curtis in South Carolina. Berkeley sent Curtis's specimen to Montagne, but apparently he did not keep a duplicate, and there is no Curtis specimen in Herb. Kew labelled *Myriangium Curtisii*. Reference to Curtis's MS. list shows that he sent numerous specimens which Berkeley noted in the list as "Collemal" only, but unfortunately Montagne did not cite Curtis's number, and none of these specimens now available in Herb. Kew is referable to *M. Curtisii*.

In Herb. Kew, under *Myriangium Curtisii*, there are three specimens. One of these is Lindig 2583, Nova Granata, which is *M. Duriaei*. Another is marked "*Myriangium Curtisii* B. on *Nyssa*. Aiken, S. C. Will try to get more of this. H. W. R.," all in Ravenel's handwriting; it has large stromata, up to 5 × 4 mm. in plan, slightly elevated apothecia, and greenish internal tissue; it is immature, but appears to be *M. Duriaei*. The third specimen is "H. W. Ravenel. Fungi Americani Exsiccati 332; *Myriangium Curtisii* Berk., in cortice *Nyssa*. Aiken, S. C."; it contains specimens on bark in bad condition and indeterminable, and a twig bearing stromata which match the previous Ravenel specimen, immature, but apparently *M. Duriaei*. Thus there does not appear to be any specimen of *M. Curtisii* in Herb. Kew.

In Herb. Montagne, there is a specimen marked "*Myriangium Curtisii* Berk. and Mont." in Broome's handwriting, with "Mont., Ann. Ser. 3, t. 12, 1849" added by Montagne, and another, apparently part of the same gathering as the foregoing, marked by Berkeley "*Myriangium Curtisii* Berk. and Mont. Car. Inf.," and by Roussel "ex clar. Berkeley, 1853," both of which appear to be *M. Duriaei*. There are also an American specimen from Sprague, which is *M. Duriaei*, and Lindig 2583

already referred to. In addition to these, there is a specimen marked by Montagne, "*Myriangium Curtisii* Berk. and Mont. Car. Inf. Amer. Boreal.," which is enclosed in a piece of paper bearing the inscription, "*Myriangium.* The best specimen" by Curtis; this has the large apothecia of *Myriangium Curtisii*, and is probably the type. Another specimen "1442 Car. Inf." appears to be part of the same collection as the foregoing, but is labelled by Montagne, "Myriangium Berkeleyi Montag. *Myriangium Curtisii* Berk. and Mont., Car. Super. [*sic*], cl. Berkeley."

It will be evident that the old herbarium specimens are somewhat confusing; and it is not surprising that later workers have regarded *M. Curtisii* as identical with *M. Duriaei*, since most of the herbarium specimens which are labelled *M. Curtisii* are *M. Duriaei*. Even Montagne's herbarium shares this confusion, though had it been consulted it would have been seen that there were two species. The best example of *M. Curtisii*, however, is in Herb. British Museum *ex* Herb. Phillips. It is labelled by Curtis, "*Myriangium Curtisii* B. & M. ad Styracem, fine specimens," and by Phillips, "*ex* Herb. Berkeley." On a mere casual glance, one is impressed by the size and shape of the apothecia.

This specimen on *Styrax* has large black stromata, which have a plicate surface and usually an abruptly sloping margin. The apothecia are sessile, *i.e.* attached over a broad base, or subturbinate, up to 0·8 mm. high; the smaller have a black upper surface, but the larger are dark grey with a brownish white margin, and up to 2 mm. in diameter. The internal tissue is brown, though there is a distinct green tinge in thin sections of young stromata, and at the base of the old stromata under a high magnification by transmitted light. The asci are confined to a narrow zone parallel to the upper surface. The specimens are accompanied by a scale insect.

Another gathering of this species was made by Professor Thaxter at Tyler City, Conn., Oct. 1888, on *Amelanchier*. In this the stromata are usually flat, rarely pulvinate, and some have a narrow, flat, plicate margin. Internally they are yellow-brown with a thick black cortex. The apothecia are close-set, up to 1·5 mm. broad, but they are black, and do not stand out prominently like those of the previous specimen; some of them are nail-shaped, *i.e.* contracted below into a narrow, stalk-like base. The spores in this gathering measure 20–24 × 8–9 μ.

The stroma of *M. Curtisii* differs from that of *M. Duriaei* in its internal colour. In this respect it resembles *M. Montagnei*, and it is closer to the latter species in the shape of the apothecia and the arrangement of the ascigerous layer than it is to *M. Duriaei*. Its spores, however, resemble those of *M. Duriaei*.

M. Montagnei differs in the shape of its spores and the consistency of the stroma.

In the available specimens, the asci and spores are smaller than those of *M. Duriaei*.

In Herb. Kew, there is a sheet marked by Massee, "*Myriangium Berkeleyi* Mass. ined." It bears two collections. One of these is marked in Cooke's handwriting, "*Myriangium* sp., on living bark of *Acacia horrida*, Cape, Kalch."; there is a black scale insect present, but nothing of the fungus remains. It may be noted that Kalchbrenner's specimens of *Microcera* were on an insect on *Acacia horrida*. The other collection is marked "*Ex* herb. Berkeley P." in an undetermined handwriting, and "*Myriangium*" by Berkeley: a drawing by Massee shows spherical asci with one-septate spores, marked "brown when mature." There is no scale insect on the latter. This second specimen is obviously not *Myriangium*, and neither is in a fit condition for determination. *M. Berkeleyi* Mass. has no relation to *M. Berkeleyi* Mont., which was apparently the name suggested by Montagne for *M. Curtisii*.

Miles has recently described *M. tuberculans*, found on *Careya illinoensis*, at Ocean Springs, Mississippi. From specimens with which he has kindly furnished me, this is *M. Curtisii*. The apothecia in the larger specimens are convex, so that the surface is facetted. The tissue is more compact than in the old herbarium specimens, and the stroma consequently less friable, again approaching *M. Montagnei*. The spores are 18–28 × 10–12 μ, rather larger than in the other available specimens, in which they do not exceed 24 × 9 μ. The specimens are accompanied by *Microcera coccophila*, the synnemata of the latter arising at the side of, or beneath, the *Myriangium*.

Distribution. North America.

Myriangium Montagnei Berk., Hooker's *London Journal of Botany*, IV (1845), p. 74. Stromata up to 5 mm. diameter, pulvinate or flattened-pulvinate, tuberculate at first, without any free margin, dark brown, appearing tomentose, becoming black and more or less shining, internally pale brown or rufous at first, becoming blackish brown when old; substance cheesy, not friable. Tubercles at first flattened-pulvinate, sessile, rarely forming obconic processes up to 1 mm. high. Apothecia discoid, with a stout rounded black margin and a sunken black or brown disc, up to 1 mm. diameter; or concave, with a narrow black margin and a rufous or pale brown disc, up to 2·5 mm. diameter; or convex, without a differentiated margin, brown or mottled, up to 2·5 mm. diameter. Asci globose, 42–65 μ diameter, or elliptical, 42–64 × 40–54 μ, exceptionally 80 × 48 μ. Spores

oval, narrow-oval, or subcymbiform, straight or curved, ends obtuse, with 6 to 8 transverse septa (usually 7), slightly or not constricted at the median septum, vertical septa tardily developed, 18–40 × 6–15 μ. *Myriangium Duriaei* Mont. and Berk. (*loc. cit.*), quoad spec. ex Swan River, Australia; *Myriangium Duriaei* Knight, *New Zealand Institute Transactions and Proceedings*, XVI (1883), p. 400; *Myriangium dolichosporum* Wilson, *Proc. Roy. Soc. Victoria*, V, p. 160 (1892); *Myriangium Acaciae* McAlpine, *Proc. Linn. Soc. New South Wales*, XXIX (1904), p. 124.

The appearance of the fungus differs greatly according to the degree of development of the apothecia. In the commoner form, judging from the available specimens, the stroma is black and the apothecia are sessile with a stout, rounded, black rim (Plate II, fig. 9). But when the apothecia have opened widely and have a convex surface, the edges of adjacent apothecia meet, so that the stroma becomes uniformly convex; and in these cases the colour is usually rufous brown or pale brown, sometimes mottled with yellow-brown. The difference in the colour of the stromata is due to the weathering or disintegration of the outer layers, and in this there are two effects, (1) removal by weathering of the outer brown tomentose or granular coat which leaves the whole stroma black, and (2) the disintegration of the upper surface of the apothecial tubercles, which exposes the inner tissues and so causes the open apothecia to be pale brown or blackish brown according to the colour of the interior. The extreme forms are so different that it was at first thought that they were two distinct species. But they occur together in several gatherings, and in one (Cheel, No. 47) both forms of the apothecium occur on the same stroma.

In general, the apothecia are sessile and the open apothecia are attached over a wide base. In rare cases they are stalked, and the open apothecia may then be nail-shaped, as may occur in *M. Curtisii*. In the unopened apothecium, the asci occupy a lenticular zone which is horizontally narrow-elliptic in longitudinal section (Plate III, fig. 7), as figured by Knight; if the interior of the stroma has become blackish, this zone retains a yellow-brown colour. In the widely-open apothecia, the asci occupy a narrow zone parallel to the surface (as in *M. Curtisii*), and this may be darker than the context, probably owing to atmospheric action (Plate III, figs. 5, 6).

The immature spores are narrower than the mature spores. The longitudinal septa are tardily developed, and the transverse septa are always the more distinct. There is a marked difference in the size of the spores in the available collections, but it has not been possible to associate this difference with any other character.

In the type of *M. Montagnei* in Herb. Kew (Drummond, No. 262), there are two specimens. One, consisting of a piece of wood, bears thin, dark brown, flat stromata, 2 × 0·75 mm. in plan, tomentose, slightly tuberculate, sometimes radially striate or ridged; this appears to be immature. The other, on a twig, is flat, with polygonal, close-set, slightly elevated, flat-topped tubercles, 0·7 mm. diameter; some specimens are purple-brown, others black and more or less shining; they are pale brown internally; this again appears to be immature. There is also in Herb. Kew, a drawing marked "*Myriangium Montagnei* Berk.," with descriptions in French (? by Montagne), which shows the spores either muriform or transversely septate. The drawing bears the number 380, which is presumably the magnification; if so, the spores are 18–20 × 5–8 μ. Montagne's specimen in Herb. Paris is very poor, but, as far as external appearance goes, is the same as that in Herb. Kew.

Another specimen collected by Drummond in the same locality (Swan River) was assigned by Berkeley (*loc. cit.*) to *M. Duriaei*. This, in Herb. Kew, has blackish brown stromata, pulvinate, up to 4 mm. diameter, yellow-brown internally; the apothecia are large, sessile, up to 2·5 mm. diameter, yellow-brown, with a narrow, blackish, incurved and plicate margin. The asci are globose, 42 μ diameter, or elliptic, 42–52 × 40 μ, and the spores, 24–30 × 7–10 μ, sometimes with only transverse septa. Its appearance is different from that of the specimens assigned to *M. Montagnei*, but on the evidence of the further specimens now available it is the same species. It is associated with a scale insect.

Dr C. Knight described this species in a paper "On the Lichenographia of New Zealand" (*loc. cit.*) under the erroneous identification, *Myriangium Duriaei*. His figures show the typical unopened apothecial process (Plate III, fig. 7), and spores only transversely septate, obviously from immature specimens. He stated that the apothecium had a thick margin, that the "hymenium" was yellow-brown, and the spores, 20 × 7·5 μ, usually three-septate. There are specimens from him in Herb. Kew, received November 1883, which have apothecia with a stout rounded margin, but are immature; they are accompanied by a scale insect.

M. dolichosporum was described by Wilson from specimens on twigs of *Hymenanthera Banksii*, Maffra, Victoria, March 1889. There are specimens of this collection in Herb. Kew, No. 1081, Nat. Herb. N.S.W., Bot. Gardens, Sydney, which are associated with a scale insect (? *Aspidiotus*). In some examples the apothecia are almost sessile, but in others they are obconic, and up to 1 mm. high. Wilson described the spores as cylindrical,

simple or obsoletely septate, arcuate, somewhat acuminate at the apices, with minute guttae arranged in the longitudinal axis, 40 × 6 μ, evidently from immature specimens. He noted that the stroma does not swell when immersed in water, and stated that it contained granular gonima, usually conglomerate, 2–7 μ diameter. The specimens agree with *M. Montagnei* in all essential details, but are exceptional in their elongated apothecial processes.

Other collections of this species by the Rev. F. R. M. Wilson are included in Herb. Kew under *Myriangium Duriaei*, viz. No. 1082 Nat. Herb. N.S.W., Olinda Creek, Lilydale, Victoria, Feb. 28th, 1898; No. 1082, Nat. Herb., N.S.W., St Crispin's Well, Mount Wellington, Tasmania (no date); and (without number) Red Bluff Victoria, May 2nd, 1893. The spores in the second of these are 22–30 × 7 μ, some muriform, others transversely septate only. All three are associated with scale insects.

No. 47, E. Cheel, Sydney, on branches of *Casuarina distyla*, Centennial Park, May 13th, 1901, is included in Herb. Kew as *Myriangium dolichosporum affine*. Its apothecia vary from discoid, with a stout black margin, to widely-open without differentiated margin. Its spores are 18–24 × 6–8 μ, and it does not differ in any respect from *M. Montagnei*. This gathering is associated with a scale insect.

The type of *Myriangium Acaciae* McAlp. was collected on *Acacia dealbata* at Plenty River, Victoria. I have not seen that specimen, but Mr C. C. Brittlebank has kindly forwarded me one on *Acacia longifolia*, collected in 1907. It is associated with a scale insect. The gathering includes black, more or less shining stromata with discoid apothecia, and brown tomentose stromata with widely-open convex apothecia. In one apothecium the spores measured 28–40 × 13–15 μ, while in another they were 24–28 × 8–12 μ. McAlpine gave the spore measurement 30–38 × 11–13 μ, rarely 42 μ long.

M. Montagnei has been found in Victoria, New South Wales, West Australia, Tasmania, and New Zealand. It would appear to be the common species on scale insects in the Australian region, the records of *M. Duriaei* being, as far as they can be tested, incorrect. It has not been recorded from any other country. I have, however, a specimen of a *Myriangium* on *Chionaspis Manni* Green, on tea, from Darjeeling, India, which I would provisionally refer to this species. The stroma is pulvinate, about 2 mm. diameter and 0·4 mm. high, covered with close-set rounded tubercles which sometimes are produced into short clavate processes: internally it is brown, and of the same consistency as *Myriangium Montagnei*. Unfortunately the specimen is immature and does not contain any asci.

Distribution. Australia, New Zealand, Tasmania.

Myriangium Thwaitesii Petch, n. sp. Stromata circular, flattened-pulvinate, about 2 mm. diameter, black, rugose, generally umbilicate in the centre at first; apothecial processes little elevated, 0·4–0·6 mm. diameter, turbinate or nail-shaped, flat-topped, first produced at the edge of the stroma more or less in a ring, internally white or brownish white. Asci at first narrow-clavate, usually becoming pyriform with a distinct foot, 52–64 × 22–30 μ, sometimes oval, 45 × 20 μ, parallel to one another in a single row, forming a peripheral ascigerous zone at the apex of the apothecial process: ascus wall 2–4 μ thick, attenuated towards the foot; spores cymbiform, 23–28 × 8–13 μ, usually transversely seven-septate, with three transverse septa in each half, and longitudinal septa in all but the terminal loculi, frequently with oblique septa in the upper loculus, ends sub-acute, not notably constricted at the septa.

This species was collected by Thwaites, the specimens in Herb. Kew and Herb. Peradeniya being marked South of the Island, July 1868. The specimen in Herb. Kew was marked *Myriangium* by Berkeley, but it was not referred to in the *Fungi of Ceylon*. Subsequently it was included under *M. Duriaei* in Herb. Kew.

In section the stroma is almost white, with a black or black-brown zone at the periphery. When mounted, a slight brown coloration is seen between the cells in some parts of the section, while in others this is absent. The intercellular substance, however, is present throughout the stroma, as may be determined by staining. With chlor-zinc iodide this substance stains yellow-brown, while with eosin it becomes pink. Consequently it is only the green or brown colouring matter which is lacking, as compared with other species. Towards the exterior, this substance becomes blackish brown, and at the exterior black.

The cells of the stroma, in the available specimens, are nearly all oval or globose, and solid or thick-walled, 5–14 × 5–10 μ. Elongated cells are rare and occur chiefly in the neighbourhood of the asci; these may be rectangular or cylindric, up to 20 × 5 μ. Owing to the deficiency of colouring matter and the obliteration of the cell lumina, the stroma is not obviously parenchymatous in unstained sections, the tissue in the uncoloured parts appearing as if in continuous sheets. The cortical layer is composed of cells of the same shape as the body of the stroma; there is no palisade layer.

This species differs from all the others described here in the shape of its asci and spores, and in the structure of the stroma. As the asci are in a single layer, it would be placed in the *Saccardiaceae*, not in *Myriangiaceae*, on Theissen and Sydow's classification (*Ann. Myc.* xv, p. 441).

In the type specimen, the fungus is parasitic on a scale insect on the stem of an undetermined tree.

Distribution. Ceylon.

The microtome sections and photographs have been prepared by Mr L. S. Bertus.

Key to the entomogenous species of Myriangium.

Stroma at first green internally; ascigerous region cup-shaped. *M. Duriaei.*

Stroma yellow-brown internally; asci in a zone parallel to the surface.

Spores generally oblong-oval, septa distinct. *M. Curtisii.*

Spores generally narrow-oval, septa tardily developed. *M. Montagnei.*

Stroma white internally; asci clavate or pyriform, in a single layer. *M. Thwaitesii.*

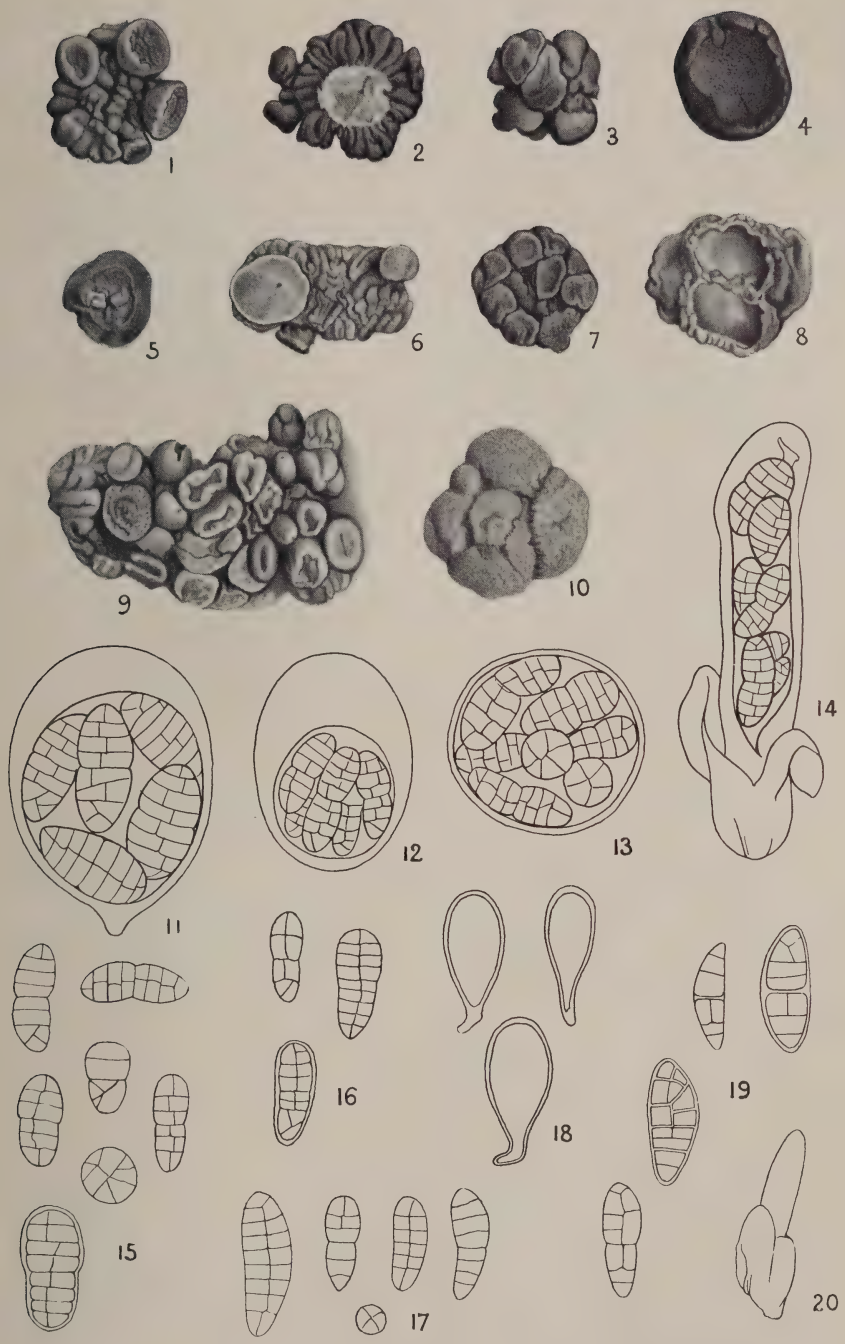
EXPLANATION OF PLATES.

PLATE II.

Fig. 1. *Myriangium Duriaei,* stroma with apothecia (England). ×6.
2. *M. Duriaei,* lower surface of stroma (England). ×6.
3. *M. Duriaei,* convex apothecia (England). ×6.
4. *M. Duriaei,* an apothecium (England). ×15.
5. *M. Duriaei, ex* co-type of *M. philippinense.* ×6.
6. *M. Curtisii,* stroma with two open apothecia (America). ×6.
7. *M. Thwaitesii* (Ceylon). ×6.
8. *M. Montagnei,* large open apothecia (Australia). ×6.
9. *M. Montagnei,* stroma bearing stout-edged apothecia (Australia). ×10.
10. *M. Montagnei,* stroma with convex apothecia (Australia). ×6.
11. Mature elliptic ascus of *M. Duriaei* (France). ×600.
12, 13. Mature asci from the same apothecium of *M. Duriaei* (England). ×600.
14. *M. Duriaei,* broken ascus (below) with extruded hyaline plasma containing the spores (Ceylon). ×500.
15. Spores of *M. Duriaei* (England). ×600.
16. Spores of *M. Curtisii* (America). ×600.
17. Spores of *M. Montagnei* (Australia). ×600.
18. Asci of *M. Thwaitesii.* ×300.
19. Spores of *M. Thwaitesii.* ×600.
20. *M. Duriaei,* broken ascus with extruded hyaline plasma from which the spores have escaped (Ceylon). ×300.

PLATE III.

1. *M. Duriaei,* vertical section through an apothecial process and part of the base of the stroma. ×40.
2. *M. Duriaei,* vertical section of a stroma, showing a shallow apothecium. ×25.
3. *M. Duriaei,* vertical section of a pulvinate stroma from the same gathering as Fig. 1. ×25.
4. *M. Curtisii,* vertical section of a single apothecial process. ×40.
5. *M. Montagnei,* vertical section of a stroma. ×18.
6. *M. Montagnei,* vertical section through an apothecial process. ×40.
7. *M. Montagnei,* vertical section through an unopened process. ×40.
8. *M. Thwaitesii,* vertical radial section through half the stroma, ×40: the lower part of the figure shows the tissues of the host plant, and the central cavity is the perithecium of another fungus immersed in those tissues.
9. *M. Thwaitesii,* vertical section through a process. ×125.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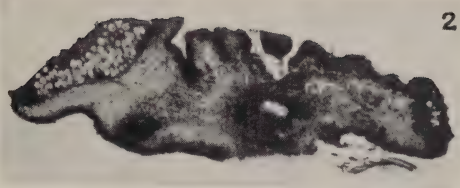
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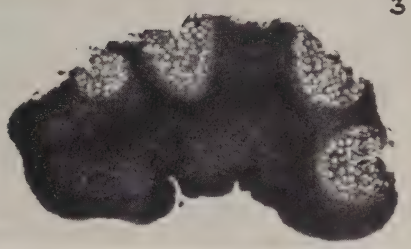
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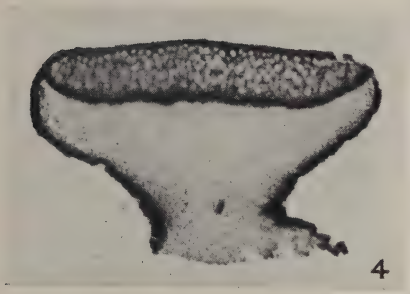
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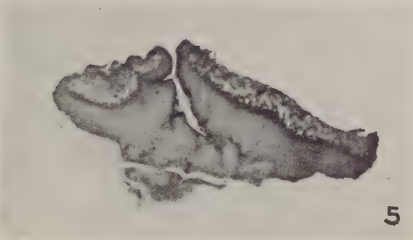
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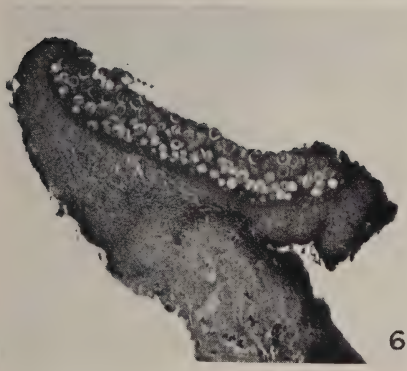
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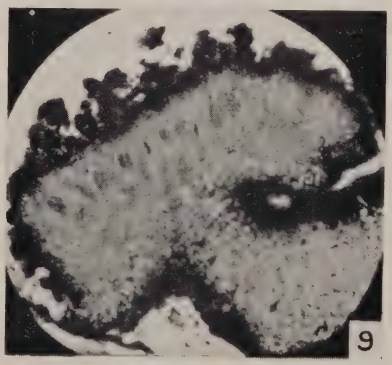
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THREE DISEASES OF CULTIVATED MUSHROOMS.

(With Plates IV and V.)

By F. E. V. Smith, B.Sc.

INTRODUCTION

THROUGHOUT the history of mushroom growing, the disease known as "la molle" has been recognised as the growers' most serious enemy. It occurs in all the districts in England where mushrooms are cultivated. Generally the attacks do not reach epidemic proportions but the disease occurs regularly with each crop of mushrooms and does sufficient damage to make an appreciable reduction in the profits, even if actual loss is not experienced. Epidemics are not infrequent in France and America, cases being on record where the industry has had to be abandoned through the ravages of this disease. The only means of control in use in England appears to be that of burning the diseased mushrooms. On the continent disinfectants have been used as preventatives with a fair measure of success.

The object of the present investigation was to study the disease as it appears in England and to see if the results of the investigations of Costantin and Dufour in France or Veihmeyer in America applied in this country also. Although the investigation was originally intended to cover only the disease caused by *Mycogone perniciosa*, it was found that the mushrooms which the grower calls "diseased" may contain one of three parasitic fungi and consequently the three diseases were investigated.

HISTORICAL.

The earliest scientific records of the *Mycogone* disease of mushrooms are those of Magnus (1888) and Cooke (1889). Magnus was unable to identify the fungus with any known species and so, although the ascus stage was not seen, he named it *Hypomyces perniciosus* by analogy with *H. chrysospermus*. Cooke stated that the fungus he found resembled both *Mycogone rosea* and *M. alba* but differed in having amber-coloured chlamydospores.

Several papers followed these in which the parasitic fungus was identified as, or referred to, the following species: *Verticillium agaricinum* (Stapf 1889); *Mycogone rosea* (Prillieux 1892); *Mycogone cervina* (Costantin and Dufour 1892); Costantin and Dufour made a very exhaustive study of the disease and after

growing the fungus side by side with *M. rosea* decided that it was a distinct species and named it *Mycogone perniciosa* (Magnus). This name has been adopted by all subsequent writers, but the systematic position of the fungus has never been thoroughly investigated. It seems remarkable that if the fungus is a distinct species it should not have been recorded in the wild state.

Costantin and Dufour investigated the fungus very thoroughly and found that it exhibited two forms of spores on the mushroom. The first to appear was a *Verticillium*-like spore which was quickly followed by the chlamydospore or *Mycogone* stage. By making separate cultures from these two spore forms they proved that they belonged to one fungus, since the growths which resulted were identical in all respects, and the two types of spore were borne on each. The diseased mushrooms were divided into two categories by these workers, namely the "commune" and the "sclérodermique" forms. The first group included those mushrooms which retained the normal shape with only slight deformity. The disease appeared on these externally as a white felt either on the stipe or on the under surface of the pileus. The second group was characterised by much greater deformity, and only those mushrooms which had a very much swollen base and greatly reduced cap were included. Quite often the pileus was entirely wanting, and such forms were called "sclérodermique" because of their resemblance to the genus *Scleroderma**. On further study it was found that neither the *Verticillium* nor the *Mycogone* spores were produced on the sclerodermoid mushrooms, but another fungus having small spores invariably appeared. This was described as "*Verticillium* à petites spores." In culture it consistently produced small spores only. It was concluded, however, in spite of this, that it was a stage of *Mycogone perniciosa* because in one instance the two fungi were found on the same mushroom. In this case they observed what were considered to be stages in the transition between the small- and large-spored *Verticillium*. This was the only observation on which the identity of the three forms was based.

In 1909 considerable outbreaks of the disease occurred in America. This epidemic was investigated by Veihmeyer (1914), who was successful in finding measures which prevented the occurrence of the disease. He found that the two types of diseased mushrooms described by the French writers were also produced in America, but he was unable to isolate or observe any fungus resembling the small-spored *Verticillium*. A *Myco-*

* For the sake of convenience the word "sclerodermoid" has been substituted for "sclérodermique" in this paper.

gone was isolated which agreed with *Mycogone perniciosa* in all respects, but it could be isolated from both the ordinary and the sclerodermoid types. Veihmeyer carried out a large number of experiments on the longevity of the spores of *Mycogone* and their resistance to certain disinfectants, notably coal oil and formaldehyde gas.

The results of these two investigations appeared to be contradictory on the question of the causal organism of sclerodermoid mushrooms. The results of the present investigation show that sclerodermoid mushrooms may be produced by two separate parasites.

THE MYCOGONE DISEASE.

(*a*) *The Diseased Mushrooms.*

In mushroom houses where *Mycogone perniciosa* has once appeared and where effective control measures are not in use, attacks of the disease occur in every set of beds made. It does not make its appearance at any particular time during the growing period of the bed, but appears sometimes when the mushrooms are just beginning to form, while in other cases evidence of the attack is not visible until the beds are beginning to "go off." The writer's experiments show that the chief factor determining the time of appearance is the quantity of infection. When there is a heavy deposit of *Mycogone* spores the attack usually appears with the first mushrooms, while a lighter infection does not produce many diseased specimens until the bed has reached the optimum of its growth.

Mushrooms infected by *Mycogone* are usually deformed (Plate V, fig. 8). In some instances the mushrooms show no outward signs of infection except deformity, while others appear quite normal in shape but bear a dense flocculent felt of parasitic mycelium either on the stipe or the gills. It is comparatively rare to find mushrooms with the parasite on the upper surface of the pileus.

The presence of the disease internally causes the mushroom to produce a very much enlarged stipe. This affects the development of the other parts so much that very often the pileus and gills are considerably reduced or entirely absent.

Thus there are transitions between two extreme types of infection from the normal mushroom with an external infection to the spherical sclerodermoid form which frequently does not show any of the parasite externally.

(*b*) *The Parasitic Fungus.* Mycogone perniciosa.

Mycogone perniciosa produces a copious flocculent mycelium on most substrata. In the early stages this is white but later

changes to a light amber brown. The hyphae are narrow (3 to 4 μ wide) and frequently septate, the cells being multinucleate and very rich in cytoplasm. Two types of spores are formed representing conidia and chlamydospores (Plate IV, fig. 1)

The conidia are thin-walled cells borne on upright verticillately branched conidiophores and are known as the *Verticillium* stage. These are the first to appear on the mushroom and may be found always at the edge of the *Mycogone* mycelium. The conidiophores consist of long and frequently branched verticils bearing conidia at the tips of the pointed branches. The conidia are produced by the formation of a constriction near the apex. The portion beyond the constriction enlarges until finally a long cylindrical spore with pointed ends is cut off (Plate IV, fig. 3). When the formation of the conidium is practically complete a median septum appears. The mature conidium is 1-septate with equal sized cells. The size of those growing on mushrooms varies between 15 to 20 μ in length with a diameter of 3 to 4 μ. The walls are quite thin and usually one or more oil drops may be seen in each cell. The frail connection between the conidiophores and conidia causes them to be shed frequently before maturity while they are still unicellular*. In some of these cases septa are formed afterwards but frequently the spores remain unicellular. Germination takes place quite readily from either one or both cells of the spore.

The chlamydospores (*Mycogone*) are formed later on short branches at the base of the *Verticillium* conidiophores and are much more resistant than the thin-walled conidia. The end of the hypha swells slightly and divides by one transverse septum. The upper cell thus formed swells more quickly than the lower and its wall thickens. Finally, a bicellular spore is formed, the upper cell of which is almost spherical with a thick stratified wall. The outer surface of the upper cell is slightly warted and the cytoplasm is dense and granular, containing several nuclei (Plate IV, fig. 2). The mature spore is light umber in colour. The lower cell remains almost unthickened and is smaller than the other. It appears to act only as a suspending cell for the upper thickened part of the spore as it is easily ruptured, and is often torn when the spore is shed. It is possible that the shedding of spores is effected by the death of these suspending cells for they do not play any part in the life of the spore afterwards. The size of the mature spore varies according to the medium on which the fungus is grown, but on mushrooms and on several agar solutions the complete bicellular spore measures from 25 to 30 μ in length at maturity. The upper thickened cell is from

* Since the majority of the spores are uniseptate, this stage would be more correctly described as the *Diplocladium* stage.

18 to 20 μ broad and 14 to 17 μ long, while the suspending cell is rarely more than 10 to 14 $\times$ 9 to 12 μ. The thin lower cell dies quickly and germination is effected by the production of a germ-tube which usually arises at the base of the upper cell. The young hypha penetrates the thinner portion of the spore wall at the base and then passes through the cavity left by the dead suspending cell. Satisfactory germination studies are difficult to carry out in hanging drops, and it has been found that the best method is to place drops of spore suspension on a mushroom agar plate. Spores removed after two days usually show stages in germination.

(*c*) *Culture Studies in Mycogone.*

In his monograph on *Hypomyces*, Plowright (1882) states that in most species of this genus the ascigerous stage is most likely to appear when the formation of chlamydospores is retarded or prevented. By analogy with other fungi it seems obvious that when the food supply is of a favourable nature the ordinary (*Verticillium*) conidia will be produced and that the fungus will be stimulated to form chlamydospores when the food supply runs short or is unfavourable. In order to test Plowright's statement and also to try to find the conditions under which the two types of spores are produced, a large number of cultures were made on various media.

In the first place, the usual series of stock agars and gelatines were used; but as the food conditions are not the only factors which might influence the growth of the fungus, variations of temperature, light and acidity were made in these experiments.

Light and darkness seem to have little or no effect, but it was soon discovered that higher temperatures accelerate growth up to an optimum of 23° to 25° C. Similarly, a higher humidity produces a much more flocculent culture, but neither of these conditions influences the proportion of either sort of spore formed beyond what would be naturally expected from a more vigorous culture.

The effect of various food materials on the quantity of spores produced is most striking. When the fungus is grown on media rich in carbohydrates such as potato, prune, macaroni and rice the growth is quite brown from the large number of chlamydospores formed. In other cases where more nitrogenous foods are available, such as nutrient agar and gelatine, mushroom agar and extract and solutions containing peptones and amino compounds, the proportion of *Verticillium* spores is considerably larger.

Zellner (1907) gives a brief analysis of the substances present in *Psalliota arvensis* and *campestris*. Using this analysis as a basis for a stock culture solution, a number of semi-quantitative

culture experiments have been made. The stock solution contained:

Potassium sulphate	4 grams.
Potassium hydrate phosphate	1·5 ,,
Sodium nitrate	1·0 ,,
Sodium chloride	1·0 ,,
Traces of ferrous sulphate and magnesium sulphate	
Water	1000 c.c.

The experiments consisted in growing *Mycogone* in tubes or flasks of this solution to which had been added substances of known composition. The results are summarised in Table I.

Table I.

Constituents added to stock solution	10 days' growth	25 days' growth	3 months' growth
A. 0·25 % each asparagin, leucin and urea	¾ inch diameter, white, sterile	2 inches white, sterile	liquid filled with white, sterile hyphae
B. 0·25 % mannite, dextrose	¾ inch white, sterile	buff to whitish, many chlamydospores, no *Verticillium*	liquid filled with mycelium, surface brown and powdery with chlamydospores
C. 0·25 % each asparagin, leucin, urea, mannite, and dextrose	1 inch, sterile	2 inches, buff, few *Verticillium*, chlamydospores frequent, not so abundant as in *B*	similar to *B* but chlamydospores not so numerous, estimated at half the number

These experiments were carried out with six tubes of each variety in order that a tube might be opened for each examination. In the case of *A* it was necessary to ascertain that the fungus was *Mycogone perniciosa*. Transfers to tubes of mushroom agar confirmed this. The experiments show that carbohydrates stimulate the formation of chlamydospores, while purely nitrogenous substances inhibit the formation of both kinds of spores. So far the writer has not found conditions favourable to the formation of *Verticillium* spores only.

(*d*) *Pathological Anatomy.*

A microscopical examination of mushrooms which have only an external infection shows that the mycelium of the parasite penetrates to a considerable depth into the mushroom tissue*.

* The *Mycogone* hyphae are easily distinguished from those of the mushroom when sections are stained in Delafield's Haematoxylin and Safranin. The parasitic hyphae are very much smaller and take up more stain owing to the greater concentration of cytoplasm. The normal diameter in *Psalliota* is about:

Stipe	inner cells 8–14μ	
	outer ,, 6–9μ	
Gills	inner cells 4–7μ	often less
	outer ,, 5–9μ	
Pileus	inner cells 8–12μ	
	outer ,, 5–7μ	

Mycogone hyphae have an average diameter of 3–4μ.

The hyphae of *Mycogone* penetrate the host by passing between the plectenchymatous cells. Enzyme secretion is very vigorous, and in prepared sections there is always a deeply stained zone around the hyphae which are growing vigorously. A section through the infected portion shows four distinct bands (Plate IV, fig. 4). The outer layer consists of a thick felt of hyphae of the parasite bearing chlamydospores and bicellular conidia. Adjoining this is a zone of brown mushroom tissue which has been killed. A few parasitic hyphae pass through this region connecting the outer felt of hyphae with the inner living tissues of the mushroom.

Inside the zone of dead tissue are two layers of mushroom hyphae in various stages of infection. In the outer layer of these there is evidence of extensive enzyme secretion. Hyphae of the parasite are very abundant and pass both between and through the cells of the plectenchyma, which show signs of disintegration. Occasional chlamydospores are formed in this region. The innermost zone has fewer parasitic hyphae as infection takes place from the outside inwards. Here the *Mycogone* hyphae pass between the host mycelium, and in some cases just penetrate the cell walls.

It appears that most of the damage is caused by enzyme action, for once infected, the mushroom quickly decomposes and becomes soft and odoriferous. To test this suggestion several cultures of *Mycogone* were made on aqueous mushroom extract in Erlenmeyer flasks. When the surface of the culture fluid was covered, the mycelium was removed and ground in a mortar with a little cold water. A piece of mushroom stipe on being treated with the filtrate from this mixture quickly became soft wherever it was thoroughly wetted.

In some cases infection takes place when the mushroom is quite small and the parasite travels upwards through the inner tissues of the stipe and finally enters the pileus. Usually the number of hyphae which pass upwards in this way is relatively small, but once the hyphae enter the pileus they commence active ramification and finally pass down the gills and burst through the hymenium, which soon becomes covered with a white flocculent felt.

SCLERODERMOID MUSHROOMS.

(*a*) *Mycogone perniciosa.*

Veihmeyer's work indicated that *Mycogone perniciosa* was present in sclerodermoid mushrooms and that the "*Verticillium* à petites spores" of Costantin and Dufour was not necessarily the parasite which produced this type of infection. A number of experiments have been carried out on mushrooms grown in

specially constructed boxes with the object of testing the statements of these two writers and also to make observations on the methods of infection by *Mycogone*. These boxes were made with a deep lid in order that the mushrooms might have plenty of air without great risk of stray spores of *Mycogone* or other fungi entering.

Mushroom beds infected by spraying or sprinkling with a suspension of *Mycogone* spores in sterile water produced mushrooms with an external infection and, in addition, a considerable number of sclerodermoid mushrooms. Isolations were made from both of these types and *Mycogone* occurred invariably not only in the culture tubes but also on all of the mushrooms themselves. In the control boxes the mushrooms were all perfectly normal. This experiment was repeated on several occasions with the same results, showing quite clearly that sclerodermoid mushrooms may be produced by *Mycogone perniciosa*.

It has been suggested that *Mycogone* attacks the spawn and that the parasitic hyphae mingle and grow side by side with those of the mushroom, finally entering the young sporophore. Careful observations were therefore made to ascertain the method of infection, and it seems quite clear that *Mycogone* infects each mushroom separately. Numerous specimens of spawn have been taken from diseased beds and examined microscopically, but none of these contained parasitic hyphae below the level of the soil except in one or two instances. These were cases when a heavy infection of spores had been mixed with the lower layers of soil, or with the dung, or else placed directly on the spawn itself. In these cases the spawn died very quickly and only one or two mushrooms were produced. It is very improbable that the parasite could grow in contact with the mushroom hyphae for any length of time, as *Mycogone* produces enzymes which rapidly break down the hyphae of the mushroom. The observations made on the beds used in this investigation lead one to believe that *Mycogone* infects the very young mushrooms from the soil. That it is capable of living and growing in the soil has been shown by cultures made on all types of soils available. It appears that the type of mushroom produced varies with the degree of its development at the time of infection. Thus sclerodermoid mushrooms develop from an infection previous to the differentiation into stipe and pileus while those with rudimentary caps become infected at a slightly later stage. This has been shown in beds which have been infected by spraying when the first mushrooms had arrived at the "pin-head" stage. Allowing two or three days for the germination of the *Mycogone* spores, it can be reckoned that differentiation had well begun in the larger mushrooms when infection took place. The first mushrooms to

appear in this experiment were either undiseased or had only a small external infection. The mushrooms which appeared later were more and more heavily infected until finally they were practically all either sclerodermoid or very much deformed. A similar state of affairs occurs to a smaller degree in most infected beds, the sclerodermoid mushrooms appearing more abundantly as the bed becomes older. This is partially accounted for by the many broken strands of mycelium left when the diseased or healthy mushrooms are removed. These broken ends frequently round off and form new buttons which are readily attacked by the *Verticillium* spores (conidia) liberated from those mushrooms which have been removed.

Mushrooms frequently arise in clusters and it is not uncommon to find all types of diseased and healthy mushrooms in the same cluster (Plate V, fig. 8). This may be explained by one or two of the older specimens having been infected from the soil and the disease passing from them to those which are less developed.

(*b*) *Cephalosporium.*

During the summer of 1923 the writer obtained specimens of diseased mushrooms from growers in four different districts in order to isolate the fungi present in them. Isolations were made by cutting out a small cube of the diseased tissues with a sterile scalpel and after being passed through a flame it was transferred to a tube of culture medium*. The cultures were stored in a cool cupboard to reduce bacterial growth to a minimum.

In three of the consignments received most of the mushrooms were of the slightly deformed type—typical of *Mycogone* disease. In all these cases *Mycogone* appeared both in culture and on the mushrooms themselves. Only one mushroom in these three consignments was similar to the sclerodermoid mushrooms grown by the writer. This specimen produced *Mycogone perniciosa* on its cut surfaces, and also pieces placed in culture tubes showed the same fungus.

The fourth consignment was quite different from the others, all the mushrooms being either spherical or invertedly pyriform. They differed from the sclerodermoid mushrooms which the writer had been acquainted with previously, not in shape but in texture and in appearance. The sclerodermoid forms in which *Mycogone* is present are usually whitish, very soft and moist in texture and putrefy very quickly. This sample, however, was

* For this purpose acidified carrot, mushroom or coconut agar or carrot slants are most suitable. Coconut agar is an excellent medium and is prepared from a decoction of 65 grams of commercial desiccated coconut in 1000 c.c. water.

dry and elastic while the surface was light to dark brown and slightly hairy, exactly similar to the surface of the pileus of *Psalliota arvensis**.

The mushrooms did not decompose very quickly and in culture produced, without exception, a fluffy quickly growing fungus which was perfectly white. The same fungus appeared on the cut surfaces of the mushrooms. Several samples of mushrooms from this source have been received from time to time, and invariably the same fungus has appeared. There were a few mushrooms amongst these consignments which have the slight deformations typical of the *Mycogone* disease. In these few cases *Mycogone* has been isolated, but the same white fungus has occurred in all the sclerodermoid mushrooms received from this grower.

On examining this fungus microscopically it was found to consist of frequently branched hyphae with masses of small hyaline spores exactly similar to the spore masses in the genus *Cephalosporium* (Plate IV, fig. 6). The fungus remained constant when grown on all types of substrata and no other method of reproduction has occurred. On comparison with the description by Costantin and Dufour of their "*Verticillium* à petites spores" it was found to agree exactly, and it is concluded that these sclerodermoid mushrooms are identical with those found by Costantin.

The fungus does not appear to have been further described, and the name *Cephalosporium Costantinii* is proposed for it.

Cephalosporium Costantinii nov. sp. Mycelium, white, floccose. Hyphae, creeping, septate, 0·75 to 1·25 μ in diameter, frequently and more or less regularly branched. The branching is frequently subverticillate in the upright portions. Conidiophores, continuous, occasionally cut off at the base by a septum, lateral or terminal, of varying lengths arising either on the main or lateral branches of the hyphae, upright or subdecumbent, of the same diameter as the hyphae. Conidia, oval to subreniform, hyaline, unicellular, 3 to 4 $\mu \times$ 1 to 1·5 μ, occasionally longer (7 μ), usually broader than the conidiophore. Conidia are cut off singly at the end of the conidiophore but remain clustered around the tip in spore masses. Spore masses, large up to 50 μ in diameter, containing large numbers of conidia, semi-persistent.

[*Cephalosporium Costantinii.* Mycelium album, floccosum. Hyphae repentes, septatae, 0·75–1·25 μ diam., saepe et plus minusve regulariter ramosae, ramis erectis saepe subverticillatis. Conidiophora aseptata, interdum ad basim versus uniseptata,

* The cultivated mushroom is often a variety of *P. arvensis*.

lateralia terminaliave longitudine variabilia, e hypha primaria vel e ramis exorta, erecta vel subdecumbentia, 0·75–1·25 μ diam. Conidia ovalia vel subreniformia, hyalina, unicellularia, 3–4 $\mu \times$ 1–1·5 μ, interdum longiora (7 μ) quam conidiophora plerumque crassiora, singulariter e conidiophori apice abstricta, sed in capitula collecta. Capitula ad 50 μ diam. e conidiis numerosis composita, semipersistentia.]

In pure culture the fungus grows rapidly and is perfectly white. Spores always produced in large numbers.

As this fungus remains perfectly uniform in culture and shows no signs of any relation with *Mycogone perniciosa* it is concluded that the sclerodermoid disease may be caused by the two fungi separately. This suggests the reason why Veihmeyer's results did not agree with those of Costantin, as *Cephalosporium Costantinii* possibly does not exist in the American mushroom beds. The full pathology of the disease has not yet been worked out.

The measures which control the *Mycogone* disease apply also to *Cephalosporium Costantinii*, but as the latter grows much more readily on sterile dung and pieces of spawn it is probable that the disease is distributed by means of the spawn much more easily than is *Mycogone perniciosa*.

GILL MILDEW DISEASE.

In the spring of 1923 many of the mushrooms in the control beds had a slightly abnormal appearance. The shape of the fructification was quite normal, but closer examination revealed fasciation and mildewing of the gills (Plate V, fig. 9). In the first instance the abnormality was attributed to the stimulus of cultivation, as it is not infrequent to find fasciations in plants which have been subjected to excessive cultivation and nutrition. When pilei of these abnormal mushrooms were placed under a bell-jar in the laboratory, a fine web of white fungal hyphae appeared on the surface of the gills in a very short time, and as this occurred on several occasions it was assumed that the fasciation was caused by a parasitic fungus.

Isolations were made on agar from pieces of the gills of young affected mushrooms and in each instance the same fungus was produced and this was identical with that which appeared on those pilei which were kept in the laboratory. As the fungus appeared in isolations made on several different occasions it was assumed that it was causing the disease. The writer has been unable to trace any descriptions of a similar disease in the literature and proposes the name "Gill mildew" for it.

The gills of the young affected mushrooms in addition to the fasciations have a mottled appearance which later changes to a

uniform glaucous pink. In the later stages the gills become black with a fine web of mycelium covering them. The amount of the fasciation varies, but the lamellae are frequently fused in numbers of three to seven either entirely or in several places along their length.

Since its first appearance the disease has occurred in practically every bed which has been planted, and isolations from mildewed specimens at various times have shown that the same fungus is always present.

It has not been possible to obtain very much information as to the distribution of this disease, but specimens of affected mushrooms have been found growing "wild" on heaps of horse dung, and samples have been seen frequently among those exposed for sale in a town in the north of England. Specimens have also been seen in other places, but it has not been possible to trace the origin of any of these samples. It is assumed, however, that the disease is fairly widespread but practically unnoticed owing to the very small amount of damage done to those mushrooms which are affected.

The diseased mushrooms appear to be quite edible unless they are kept for some time, when the parasite produces putrefaction of the gills. The parasitic hyphae penetrate the gills but do not appear in great numbers until the later stages. They do not grow or secrete enzymes so vigorously in the mushroom tissues as do those of *Mycogone* and consequently the damage is very small. In pure culture the fungus appears as a white fluffy mycelium which produces small hyaline conidia in very large numbers. The rate of growth is high, particularly when the temperature is raised to 23° to 25° C. This indicates that the damage caused by this disease will be much greater when the weather is warm or when mushrooms are grown in a house which is too hot. The fungus grows very rapidly on sterilised dung and for this reason it is possible that it is really a coprophilous saprophyte which becomes parasitic under certain conditions.

The writer has been unable to find any means of controlling the disease, but as the damage done is not usually very severe it is questionable whether it would be profitable to undertake control measures which entailed much expense.

The parasitic fungus grows rapidly on all substrata and forms a dense white mycelium practically identical macroscopically with *Cephalosporium Costantinii* except that it is not quite so floccose. One type of spore only is formed but these are exceedingly numerous (Plate V, fig. 7).

As the fungus does not appear to have been previously described, the name *Cephalosporium lamellaecola* is proposed for it.

Cephalosporium lamellaecola nov. sp. Mycelium, white, somewhat floccose. Hyphae, creeping, septate, 0·75 to 1·25 μ, in diam., frequently and more or less irregularly branched. Conidiophores, continuous, upright to subdecumbent, of varying lengths often short (15 to 100 μ), occasionally cut off at base by a septum, arising as lateral branches of main hyphae, diameter same as the hyphae. Conidia, oval, hyaline, unicellular, 3 to 5 × 1·5 μ, occasionally longer (7 μ) or subglobose (2 μ), arising singly at the end of the conidiophore but frequently remaining in small temporary clusters (spore masses) of 3 to 10 around the tips of the conidiophores. Spore masses, small, not always spherical, frequently fan-shaped (6 to 10 μ broad), more abundant on older mycelium. Growth is rapid in pure culture.

[*Cephalosporium lamellaecola.* Mycelium album flocculosum. Hyphae repentes septatae 0·75–1·25 μ diam. saepe et plus minusve irregulariter ramosae. Conidiophora aseptata, erecta vel subdecumbentia, longitudine variabilia saepe brevia (15–100 μ), interdum ad basim versus uniseptata, e hypha primaria lateraliter exorta, 0·75–1·25 μ diam. Conidia ovalia, hyalina, unicellularia, 3–5 μ × 1·5 μ, interdum longiora (7 μ) vel subglobosa (2 μ), singulariter e conidiophori apice abstricta, sed acervulos parvos temporarios (3–10-nas), apicales efformantes. Capitula parva, spherica vel conica 6–10 μ diam., in mycelio vetusto abundantia.]

Cephalosporium lamellaecola differs from *C. Costantinii* in the method of branching which is never subverticillate, in the size of the spore masses which are small, ephemeral and frequently fan-shaped and in the spores not being so constant in shape. There is very little difference in macroscopical appearance in culture except that *C. lamellaecola* is not so floccose as *C. Costantinii.*

At first it was thought that the two species might be identical or biological varieties of the same species. When mixed cultures were made with *Mycogone perniciosa*, however, it was found that the two species behaved very differently. The cultures were made on agar plates, inoculations of *Mycogone* being made on one side with one of the two species of *Cephalosporium* on the other. After incubation at 22° C. for a week *Cephalosporium Costantinii* showed attraction for *Mycogone* while *C. lamellaecola* exhibited strong repulsion. The shape of the growths in *C. Costantinii* were semi-circular, meeting at the broadest parts. The growths in the other case were shaped like a sector with an angle of 110°, the two angles being opposite. In the latter case only very little growth occurred in the region between the two points of inoculation.

As these experiments were repeated on several occasions with exactly the same results, it is quite clear that the two fungi are distinct although their appearance is very similar.

CONTROL MEASURES AND METHODS OF PROPAGATION OF THE MYCOGONE AND SCLERODERMOID DISEASES.

When a mushroom house is once infected with *Mycogone*, it can only be cleared of the disease by rigorous and careful disinfection of every part of the house and all implements, etc., which have come in contact with the diseased mushrooms. In many instances growers are exceedingly careful to remove all diseased mushrooms and all the dung and soil, but omit to disinfect the floor, walls, and roof. In consequence a number of spores which are carried into crevices by draughts remain untouched. A number of these spores are bound to be dislodged each time there is any draught, and so they are spread over the surface of the new beds with the result that crops are always infected.

For experimental purposes beds have been made in specially constructed boxes, and many infection experiments have been carried out to investigate the conditions suitable for the propagation of the disease. The boxes used for these experiments were designed so that observations could be made while keeping them as free as possible from outside infections.

From these experiments the following facts have been ascertained:

(1) Soil from infected beds is capable of infecting a second bed.

(2) Infected soil treated with 2 per cent. formalin and dried ceases to cause infection. (A control experiment was made at the same time, using untreated soil.)

(3) Small portions of dung from the surface of infected beds are capable of distributing the disease.

(4) The following solutions when used as a spray are perfectly effective for disinfecting the boxes, and it is to be expected that they will prove equally as efficient when used on a large scale:

1·5 to 2 per cent. lysol.
2 per cent. formalin.
2 per cent. phenol.
1·5 to 2 per cent. of the proprietary brands of coal-tar disinfecting fluids.

(5) 1·5 per cent. copper sulphate will kill spores with which it comes in contact, but in practice it does not seem to percolate so well as the other solutions and has proved to be insufficient for soil sterilisation.

Further experiments have been made, using a suspension of *Mycogone* spores in distilled water for the purpose of infection.

Successful infections have been made when this suspension has been used in the following ways:

(1) When placed on the spawn before being put in the bed —few infections only, but a very small crop of mushrooms, indicating that the spawn was killed by the disease.

(2) When sprayed on the top of the dung—more than 50 per cent of mushrooms infected, but a very poor crop.

(3) When mixed with the soil—90 per cent. infection.

(4) When sprayed on the surface of the bed—from 75 to 90 per cent. infection.

Infection takes place quite as readily when lime is added to the soil as it does when ordinary loam is used. Culture experiments show that *Mycogone* will grow in dung and all types of soil available both with and without the addition of lime. The growth was not large in these cultures but nevertheless it penetrated right through the various soils. It appears that when spores of *Mycogone* fall on the surface of the beds, they germinate and continue to live in the soil or dung until they reach the spawn or young mushrooms.

It is impossible to apply control measures which will affect the disease and yet leave the mushrooms unhurt. The method which has proved most efficient in dealing with the disease is that of watering the diseased portions of the beds with one of the disinfecting fluids mentioned. This, however, kills the mushroom spawn also. Diseased mushrooms should be removed and burnt as soon as possible, while the bed within a radius of two or three feet of the spot whence they are taken should be treated with disinfectant. Sufficient solution should be applied to saturate the bed to a depth of several inches. Formalin is preferable for this purpose as the gas given off kills the mushroom fly which is one of the chief distributing agents inside the houses. Disease appeared in a box which was previously free, after a number of flies taken from a diseased mushroom were placed inside the cover. Cultures of *Mycogone* and *Cephalosporium* have also been made from these flies.

When the bed has finished cropping, the manure and soil should be removed to a considerable distance and the latter never used for the purpose again unless treated with formalin. If it is inconvenient to remove this from the farm or garden in which the mushroom houses are situated, it should be treated with disinfectant or quicklime.

The floors of the houses should be sprinkled with unslaked lime, and the walls thoroughly sprayed with disinfectant, the spray being directed into all the crevices. In very severe cases it is advisable to fumigate the houses with formaldehyde gas before anything is removed. Veihmeyer (1910 and 1914) recommends

using 3 pints of formalin (40 per cent.) to 1½ lbs. of potassium permanganate for 1000 cubic feet. Fumigation sterilises the beds, walls, and roof as the gas enters all the crevices, at the same time killing the mushroom fly which is instrumental in spreading the disease. It is hopeless to try to destroy the disease unless these measures are carried out, since the chlamydospores of *Mycogone* are capable of very long life, the thick wall making them resistant to extremes of atmospheric conditions.

Growers should also realise that it is essential to obtain spawn from a thoroughly reliable source. The writer has examined the beds of one of the largest growers on several occasions. On this mushroom farm quicklime is used liberally on the floors when the beds have been removed, so that the disease spores cannot be carried on the employee's boots. The implements are frequently disinfected. The result is that, although some twenty acres of floor space are in use and three-quarters of a ton of marketable mushrooms are gathered weekly, no *Mycogone* has ever appeared. This grower makes his own spawn under strictly aseptic conditions, and it behoves all growers who wish to increase their yield of marketable mushrooms, either to follow this example or else to buy spawn which is known to be made under disease-free conditions. The experiments which have been described show that the disease can be carried by spawn.

Some growers have houses made with low-thatched roofs, nothing being placed inside the straw. This method cannot be too strongly condemned as the straw harbours both spores and the flies which carry them. Whenever the straw is touched a number of spores are shaken on to the beds beneath. In one set of such houses which were examined the grower stated that he had never had a bed of mushrooms which were entirely free from the disease.

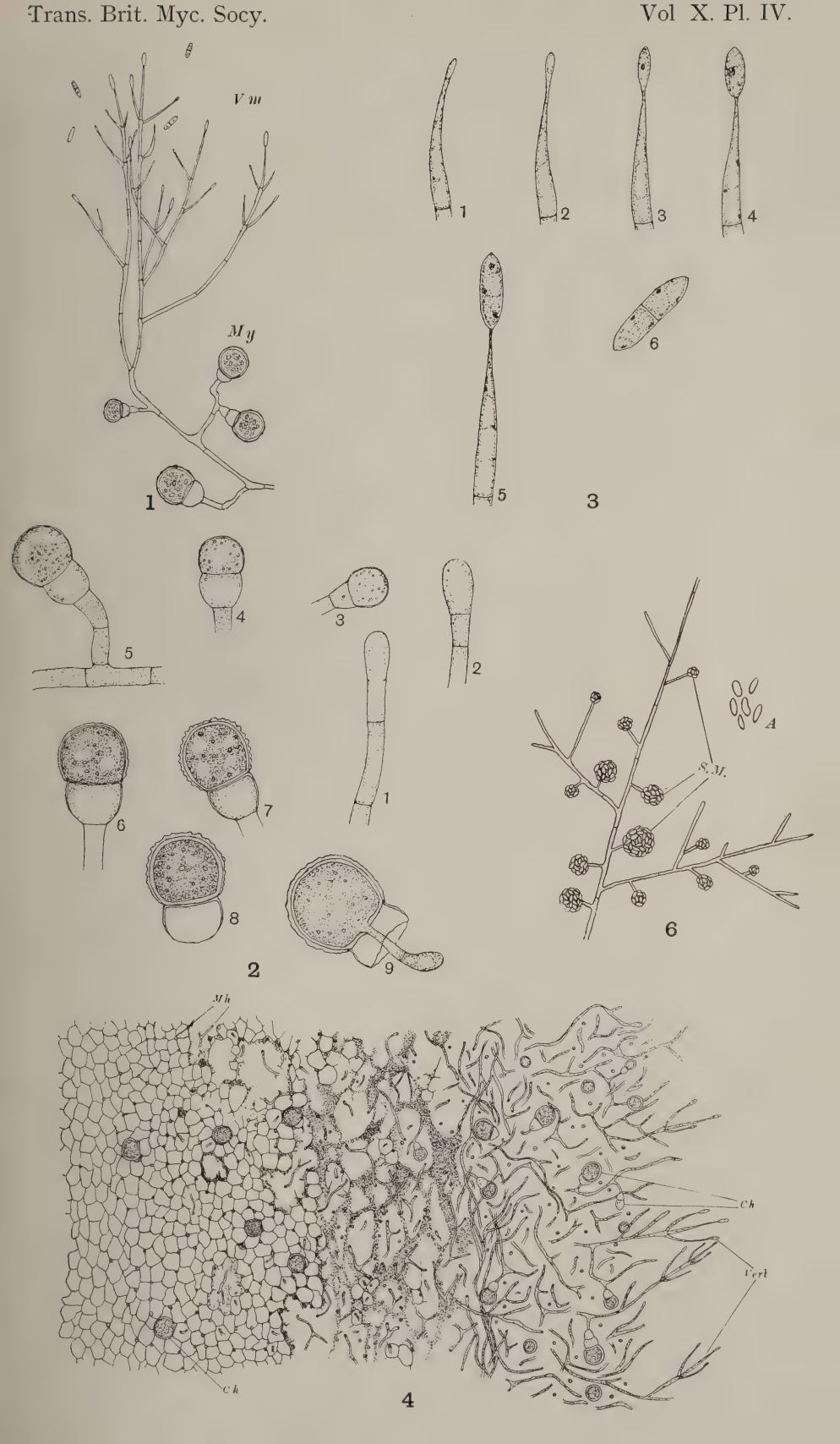
SUMMARY.

1. Mushrooms are subject to disease caused by one or any of three parasitic fungi, *Mycogone perniciosa, Cephalosporium Costantinii* n.sp., or *Cephalosporium lamellaecola* n. sp.

2. Sclerodermoid mushrooms may be produced by *Mycogone perniciosa* or *Cephalosporium Costantinii,* the latter being identical with the "*Verticillium* à petites spores" of Costantin and Dufour.

3. The pathology of *Mycogone perniciosa* has been investigated in detail. It is shown to be distributed by infected soil or spawn; usually each mushroom is infected directly from the soil in the early stages of its development.

4. *Mycogone perniciosa* may be controlled by fumigation or spraying with formalin or lysol and by soil sterilisation.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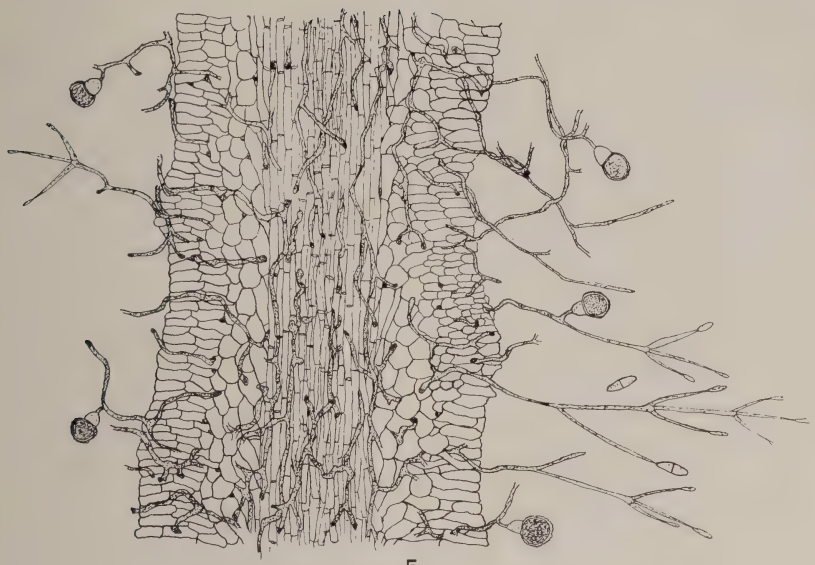

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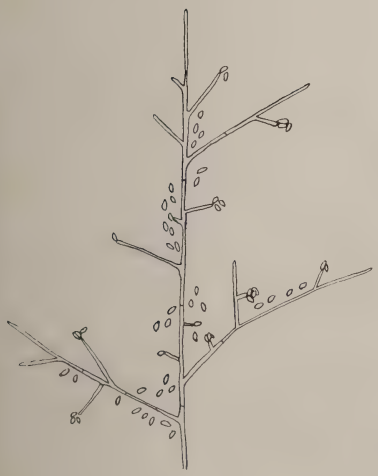

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The writer wishes to thank Mr J. Ramsbottom, M.A., O.B.E., for his great help in the systematic work. Prof. O. V. Darbishire, B.A., Ph.D., suggested this investigation to the writer who owes him many thanks for his constant interest, help, and advice during the progress of the work. The Department of Scientific and Industrial Research gave a grant in aid of the investigation and the Colston Research Association of Bristol University has kindly made a grant towards the cost of the plates illustrating the paper.

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Botany Department,
University of Bristol.
Jan. 1924.

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EXPLANATION OF PLATES IV AND V.

Fig. 1. *Mycogone perniciosa.* Portion of mycelium showing verticillate conidiophore bearing *Verticillium* conidia (*Vm*) and chlamydospores (*My*). ×250.

Fig. 2. *M. perniciosa.* Stages in the development of chlamydospores. (9) First stage in germination. ×500.

Fig. 3. *M. perniciosa.* Stages in the development of the *Verticillium* spore. ×600.

Fig. 4. *M. perniciosa.* Transverse section of stipe of diseased mushroom, showing outer layer of parasitic hyphae; the zone of dead tissue and the inner zones where the *Mycogone* hyphae are penetrating between the plectenchymatous cells. *Ch*, chlamydospores. *Vert*, *Verticillium* spores. *Mh*, *Mycogone* hyphae. ×160.

Fig. 5. *M. perniciosa.* Transverse section of diseased gills, showing the parasitic hyphae passing down the centre of the gill and finally breaking through the hymenium and forming spores. ×300.

Fig. 6. *Cephalosporium Costantinii.* Showing short conidiophores, spore masses (*S.M.*) ×300 and individual spores (*A*). ×600.

Fig. 7. *Gill Mildew Disease.* Portion of the mycelium of *Cephalosporium lamellaecola* showing short conidiophores, spores and branching. ×300.

Fig. 8. *M. perniciosa.* Photograph of a cluster of diseased mushrooms, showing slightly diseased form and also a sclerodermoid mushroom. Note drops of black liquid exuded, this is rich in destructive enzymes. ×⅔.

Fig. 9. *Gill Mildew Disease.* The underside of a pileus in the early stages of attack by the disease. Note the fasciated gills. ×1.

APPLE ROT FUNGI IN STORAGE.

(With Plates VI and VII.)

By M. N. Kidd, B.A., and A. Beaumont, B.A., Food Investigation Board, Department of Scientific and Industrial Research.

Introduction.

The following account of apple rot fungi is based on a systematic investigation of all the rots which developed on certain groups of apples during the storage seasons 1921–22, 1922–23. One thousand seven hundred and ninety-five isolations have been made and practically all the fungi are now identified. The apples used in the first season were Bramley's Seedling from four localities, each having a different type of soil—Chalk, Fen, Sand and Silt, and, in the second season Bramley's Seedling, Allington Pippin and Bismarck on Chalk. Occasional isolations from other varieties have been included.

The distribution and intensity of attack in storage of the different fungi are not here discussed in detail because they are to be dealt with in another paper by one of the writers (20).

It is well known that many fungi isolated from diseased tissues may not necessarily be responsible for the decay but merely follow the attack of other organisms. On this account, inoculations from single spore cultures of most of the fungi described have been made on healthy apples under controlled conditions, with subsequent re-isolations to establish their pathogenicity.

The inoculation method was as follows. Small pieces of glass tubing about 2 mm. long, previously plugged with cotton wool, were fastened by means of luting wax to the surface of the apple, and then were partially filled with sterile liquid media (having a capacity of less than 1 c.c.), and spores of the fungus sown in the liquid. By this method germination takes place under favourable conditions and every facility is given the fungus to invade the healthy tissue*. The ordinary method of wounding the healthy tissue and inserting the dry spores in the wound was used occasionally.

Historical.

The literature dealing with the fungi which infect apples in storage is very scattered, and as no investigators have hitherto

* This method of inoculation was first worked out by us during the course of research on the factors controlling invasion of fungi—an account of which will appear in due course.

The majority of inoculations were made on Bramley's Seedling.

attempted a detailed survey of such rots it is also very incomplete. In fact much of the existing information on apple rot fungi in storage can only be obtained indirectly.

Schneider-Orelli (33) in Germany, conducting an investigation on the effect of temperature conditions on growth and dissemination of rot-producing fungi on storage fruit, gives the following as occurring on apple:

Botrytis cinerea Pers.
Penicillium glaucum Link.
P. italicum Wehm.
Monilia fructigena Pers.
Gloeosporium fructigenum Berk.
Gloeosporium album Osterw.
Fusarium putrefaciens Osterw.
Cladosporium herbarum Pers.
Mucor piriformis Fisch.
Rhizopus nigricans Ehrenb.

Ames (1), and Brooks and Cooley (2), studying the effect of temperature and growth on the living host with fruit rot fungi in America, give the following as common apple rot-producers:

Monilia fructigena Pers.
Penicillium expansum (Link) Thom.
P. digitatum (Pers.) Sacc.
Rhizopus nigricans Ehrenb.
Glomerella rufomaculans Berk.
G. cingulata Atkins.
Thielaviopsis paradoxa (de Seyn) v. Höhn.
Cephalothecium roseum Corda.
Aspergillus niger van Tiegh.
Botrytis cinerea Pers.
Fusarium radicicola Wollenw.
Neofabraea malicorticis (Cord.) Jackson.
Sphaeropsis Malorum Peck.
Volutella fructi Stev. and Hall.
Pestalozzia funerea Desm.

Él. and Ém. Marchal (24), in a comprehensive account of fungi isolated from rots on different fruits under storage and other conditions in Belgium, give the following as having been isolated from diseased apples:

Diaporthe perniciosa É. and É. March.
Fusicoccum Malorum Oud.
Dothiorella vinosa É. and É. March.
Fuckelia conspicua É. and É. March.
Gloeosporium album Osterw.
Goetrichum candidum Link.
Botryosporium diffusum Corda.
Eidamia acrimonioides Harz.
Penicillium glaucum Link.
P. flavum É. and É. March.
Cephalothecium roseum Corda.
Cladosporium herbarum Pers.
Alternaria tenuis Nees *v.* Mali É. and É. March.
Tilachlidium Malorum É. and É. March.
Isaria felina Fr. *v.* pirina É. and É. March.
Graphium fructicolum É. and É. March.
Stysanus stemonites Corda.
Tubercularia piricola É. and É. March.
Dendrodochium pulchrum É. and É. March.
D. versicolor É. and É. March.
Fusarium Solani Mart.
F. coeruleum Sacc.

Finally Brown (6) working in this country on temperature effects on germination and growth of fungi, and Horne (43), studying the development of apple rot fungi in cold storage, record the following as common rot-producing fungi:

Alternaria Grossulariae Jacz.
Botrytis cinerea Pers.
Sphaeropsis Malorum Peck.
Penicillium glaucum Link.
Rhizopus nigricans Ehrenb.
Cephalothecium roseum Corda.
Phoma roseola Desm. (later identified as) Polyopeus purpureus Horne.

PHYCOMYCETES.

RHIZOPUS NIGRICANS Ehrenb.

We have isolated this fungus only in one or two instances, and always on early varieties of apples such as Stirling Castle. The rot is soft, light brown in appearance and apparently spreads rapidly through the fruit. The mycelium appears through the lenticels and there produces numerous sporangiophores.

ASCOMYCETES.

DISCOMYCETES.

SCLEROTINIA FRUCTIGENA Woron. see *Monilia fructigena* Pers.

PYRENOMYCETES.

PLEOSPORACEAE.

PLEOSPORA POMORUM Horne.

This species was first described as occurring on apple fruit by Horne in 1920 (17). It is very similar in its perithecial stage to both *P. herbarum* Rab. and *P. Lycopersici* É. and É. March. but differs from them in having a conidial stage which resembles the genus Stemphylium instead of Macrosporium.

The Pleospora isolated by us from Bramley's Seedling and other varieties of apple appears to be identical with *P. pomorum* except in the size of its perithecia which are never larger than 600 μ, whereas Horne gives the diameter as about 1 mm.

In culture the fungus grows well on most media, but shows great variability in the development of its reproductive organs when first isolated from the diseased tissue, so much so, as to suggest the presence of distinct physiological strains, although spore measurements and other morphological characters are identical. This variability seems to be lost with subsequent culturing. In some cultures, notably in isolations from Bramley's Seedling off Chalk soil, 1922, masses of conidia with very little mycelial growth were developed in about fourteen days at room temperature; the perithecia appearing much later. In other cases the perithecia developed simultaneously with the conidia or even in advance of them.

Horne (17), in discussing the occurrence of this fungus, considered it to be associated, under natural conditions of the orchard and storage, essentially with "spots" (that is to say, producing small discoloured areas about 2 mm. diameter) and rarely developing into actual rots, although by inoculation experiments he showed it to be capable of parasitising the fruit. We have found that, although frequently isolated from such spots, it is also responsible for quite appreciable loss during storage.

The rot can be easily recognised. It usually arises at a lenticel and is at first dark brown in colour, later becoming black, the margin being definite or indefinite, and regular or irregular. Before it has reached any considerable size, however, perithecia develop as subemergent bodies, more or less globular with a prominent neck. No asci appear to be formed nor are conidia associated with the fungus while it attacks the fruit, though both develop freely in culture.

PLEOSPORA HERBARUM Pers.

This widely distributed fungus has been obtained only once, on the variety Bismarck. The rot was large, brown and shallow and developed from a lenticel.

Both perithecia and conidia (*Macrosporium commune* Rab.) appear in artificial culture. Neither stage has been hitherto recorded on the apple.

VALSACEAE.

DIAPORTHE PERNICIOSA É. and É. March.

This fungus is described by Él. and Ém. Marchal (24) who found it in Belgium attacking both the fruit and branches of the Pear, Apple, Plum and Peach. That it occurs also in this country and is a common cause of the well-known "Die-Back" of stone-fruit trees has been shown by Cayley (8). She finds that it occurs in both Cambridgeshire and Kent, from both of which counties the apples used in this investigation were obtained, so that although it is not recorded as infecting the apple trees themselves, there seems little doubt of the source of infection of the fruit.

When apples are stored for any considerable period the importance of this fungus is second only to that of *Penicillium expansum*, but being essentially a late storage rot, it is relatively unimportant during the short period apples are normally kept.

The rot is at first smooth, rather dark brown, often lighter at the margin. It spreads laterally and towards the centre of the apple in a uniform manner, unlike rots caused by *Polyopeus purpureus* var. *verus*, which spread more rapidly through the surface tissues than internally. When once the fungus has gained an entrance the rot progresses steadily until the apple has become brown throughout. At this stage the surface of the apple is still smooth and relatively firm to the touch with no external signs of mycelial growth or of fructifications. Very soon, however, small black bodies appear under the skin, often densely crowded together; these are masses of closely packed mycelium which ultimately emerge through the epidermis as

small, semi-globose, grey-black stromatic bodies, 200μ in diameter, which up to the present have remained sterile, so that it is impossible to state whether they are immature pycnidial or perithecial stages. The absence of necks does not negate the possibility of their being undeveloped perithecia, as, under cultural conditions, these are a late stromatic development.

The fungus grows well, though slowly, on most artificial media. On Crabill's synthetic agar, the manner of growth is very characteristic. The pycnidial stage forms a compact, robust white mycelium and darkens the middle region of the slant; the stromata, which are irregular in size and shape, appear after $1\frac{1}{2}$–3 months and are at first covered with brown mycelium, afterwards becoming smooth and black. Orange-pink masses or strings of spores exude later. The perithecial stage develops more slowly, showing scanty, white, fern-like, mycelial growth and no discoloration of the media; flattened brown-black stromata appear after three or four months, and the necks of the perithecia develop about a month later. These are brown-black when young, black usually with paler tips when mature, and straight or irregularly curved. The spores are exuded in buff-coloured masses.

Some inoculation experiments have been carried out at different times. Rots were readily formed when pycnospores were used and less readily from hyphae from perithecial cultures. Pycnidia developed and exuded spores on apple twigs and inoculations have been successful on the living tree but the experiments are not yet completed.

Diaporthe perniciosa is distinguished from *D. Mali* and *D. ambigua*, both of which occur on apple branches, by the very much longer necks and by the size of the spores. The spores of *D. Mali* are larger ($18–25 \times 4–6\mu$) and its necks are very short. The necks of *D. ambigua* are rarely elongate and the spores are slightly longer (15μ) and not constricted in the middle.

The identification of the pycnidial stage presents certain difficulties. Though the primary division of the stromatic section of the Sphaeropsidales is into those forms which have only one pycnidium embedded in the stroma (unilocular) and those having one to many (plurilocular), this distinction is of limited value, because of the variable character of the fungi in culture. The pycnidial stage of *D. perniciosa* shows all stages from a fairly regular single pycnidium embedded in a stroma to pycnidia with incomplete cross walls which in some sections would be thought to be plurilocular. To be definite on this point it is necessary to cut a complete series of sections of the stroma. Plate VII shows four sections of such a series. Él. and Ém. Marchal identified the pycnidial stage of *D. perniciosa* as

Fusicoccum Malorum Oud. and they figure stromata of the fungus with several pycnidia. We have, however, made sub-cultures from specimens kindly sent to us by Professor Marchal and by cutting microtome sections of stromata from these cultures, we have been able to trace the connection between all the irregular lobes of a pycnidial cavity, which in many sections appear to be separate pycnidia. The lobing is so complex that there is no plane in which all the connections between the lobes are visible.

The stroma must therefore be considered to be unilocular and the fungus cannot be placed in Fusicoccum or any other genus whose essential character is to possess two or more pycnidia in a stroma.

Cayley (8) placed the fungus in the genus Phomopsis. There are only two genera with unilocular pycnidia, Phomopsis and Dothiopsis, between which the only difference seems to be the frequent presence of filiform spores in the former. The two genera were founded at the same time (1884), Dothiopsis being split off from Dothiora and Dothiorella, and Phomopsis from Phoma. The genus Dothiopsis has received very little attention since; Diedicke (12) states that the structure of its stroma resembles that of Phomopsis and Plenodomus, but does not draw any conclusions as to its systematic relationships. Further investigation of the genus may lead to its fusion with Phomopsis.

The occasional presence of two types of spores, filiform, and hamate spores, $25–30 \times 1–1{\cdot}5\mu$, in addition to the more normal ovate, elongate, spindle-shaped spores, $6–8 \times 2–3\mu$, cannot be regarded as a generic character since such occur in numerous species of most of the genera in the stromatic group (16).

In 1870 Nitschke (26) when establishing the genus Diaporthe called the former "stylospores" and stated that they frequently occurred in the pycnidia. Saccardo in his diagnosis of the genus Phomopsis also mentions the occasional presence of stylospores and Diedicke (11), who first showed that they were spores and not paraphyses, called the oval spores A-spores and the stylospores B-spores.

Several species of Fusicoccum possess both A- and B-spores, *e.g. F. viticolum* (34). They are not, however, specifically referred to in the original description of *Fusicoccum Malorum.* Unfortunately no drawings or cultures of the type are available, so it is impossible to be certain that they were not overlooked by Oudemans or regarded as conidiophores. An examination of sub-cultures from Marchal's pycnidial stage showed the presence of B-spores only in the young stroma, but A-spores developed later. In older cultures A-spores alone were found.

It is evident that the fungus is one of a group in which there

are no sharp lines of demarcation between the genera, and it is therefore essential when identifying a specimen to consult the descriptions of all known species in the group. We find that there are several species whose description would be appropriate for the pycnidial stage of *Diaporthe perniciosa*.

In the first place, *Fusicoccum Malorum* as described by Oudemans is identical with the present fungus, as we have shown that apparently separate pycnidia are really chambers of a single labyrinthiform pycnidium. It is, moreover, the only fungus of the group recorded on apple fruit in Saccardo's *Sylloge*.

The next species to consider, taking them in chronological order, is *Phomopsis Mali* Roberts (29, 30). This fungus causes a "rough bark" disease of apples and is capable of producing a rot on the fruit; it is very similar in its mode of attack to the "Die-Back" of stone-fruit trees in this country. As a result of an interchange of cultures, there is little doubt that *Phomopsis Mali* and the pycnidial stages of *D. perniciosa* obtained by Marchal, Cayley and ourselves are similar in general character of the stromata, size of spores and behaviour on Crabill's synthetic media.

This being so the name *Phomopsis perniciosa* f. *pruni* tentatively put forward by Cayley will have to give place to the earlier name *Phomopsis Mali*.

More recently, two American investigators, Chupp and Clapp (9), have described a fungus causing rotting of apples to which they have given the name *Fusicoccum Pyrorum*.

They state that the fungus closely resembles *Fusicoccum Malorum*, but having found it impossible to obtain specimens of the latter for comparison, they decided to create a new species.

They very kindly have allowed us to examine cultures of *F. Pyrorum*—and we believe it to be identical with *Phomopsis Mali*.

SPHAEROPSIDEAE.

PHOMA FULIGINEA sp. nov.

Pycnidiis atris, subglobosis, non ostiolatis, 250 μ diam., sporulis hyalinis, ellipsoideis, $5–7 \times 2–3 \mu$, in cirros non exsilientibus; hyphis hyalinis; substrata artifacibus fuligineis.

This species has been isolated from Bramley's Seedling three times, from a small red sunken "spot" 2 mm. in diameter, from a small spot associated with an insect puncture and from a nondescript calyx rot.

PHOMA BISMARCKII sp. nov.

Pycnidiis brunneis, subglobosis, circa 300 μ diam., ostiolis multis, nigris, 30 μ diam., sporulis hyalinis, ellipsoideis, $5–8 \times 2–3 \mu$, in cirros roseolos exsilientibus.

Isolated once from the variety Bismarck. The rot was dry, shallow and brown, arising at a lenticel.

POLYOPEUS PURPUREUS.

vars. VERUS, NIGRIROSTRATUS, LATIROSTRATUS and INCOLORATUS, Horne.

The genus Polyopeus, which was founded by Horne in 1920 (17), is distinguished from Phoma by the fact that under certain conditions the pycnidia develop tubular outgrowths or "necks." These necks vary in length from 48–240 μ and in number from one to several on a single pycnidium. They are well developed in culture, especially on Crabill's synthetic agar*, and generally on all media on which the fungus grows well. Distinct necks are also usually seen in cultures on sterilised apple twigs. But the development of protuberances must be regarded as essentially a cultural character, for on the apple the pycnidia are not distinguishable from those of Phoma and Horne diagnoses his species and varieties according to their behaviour on Crabill's synthetic agar.

Horne has regarded the fungi of this group as being associated only with the spotting of apples and does not include them among the common rot-producing fungi (43); but in our statistical survey of storage rots we have isolated from rots of considerable size fungi corresponding in cultural character to all four varieties of *Polyopeus purpureus*. In the earlier examinations they comprised the larger proportion of the fungi attacking the fruit. *Polyopeus purpureus* var. *verus* was the dominant variety, the others being comparatively infrequent. The rots caused by the different varieties are very similar in appearance. In some cases they are dry, brown, shallow, irregular in outline and progressing very slowly, but more commonly the diseased areas are smooth and circular with the edge sharply defined. In almost every case they arise at a lenticel. In colour they are bright brown often with a slight purplish tinge. Subepidermal pycnidia sometimes appear as brown, globose bodies but these, except in rare cases, remain sterile. Only *P. purpureus* var. *verus* has been observed to produce spores on the apple—by ourselves on Stirling Castle (see Plate VI) and by Horne on this variety and on Early River. On Stirling Castle the pycnidia developed and exuded spores freely when the rot was little more than two centimetres in diameter. The apples were not wrapped and the disease spread rapidly in the store. The rots are firm and rather dry, the apple ultimately becoming hard and mummified. Rots have been produced by artificial infection with all the varieties.

The fact that Polyopeus fructifies so rarely on the apple and

* Substituting wheat starch for maize starch.

is as yet known on no other host raises the question of the source of infection. It suggests the probability that it occurs in the orchard on the apple tree or on other hosts, perhaps there producing a different type of spore or even forming pycnidia indistinguishable from those of Phoma. Cultures on sterilised apple twigs spore freely. In some cases the pycnidia develop small necks but this character is not very pronounced.

POLYOPEUS POMI Horne.

This species, which is characterised by the size and number of the beaks of the pycnidia, has only been found by us in mixed infections and then very rarely. No inoculations of apple with this species have yet been carried out.

POLYOPEUS RECURVATUS Horne.

Although frequently isolated from spots we have only twice isolated this fungus from an actual rot—in both cases these were small, dry, slowly developing rots. Its pathogenicity has not yet been established.

CYTOSPORELLA MALI Brun.

This species was described by Brunaud in France in 1893 (7) on apple branches. It has not before been recorded on the fruit. It has only been isolated once by us from a large brown rot covered with small black, sterile pycnidial bodies.

CYTOSPORA PERSONATA Fr.

Fungi belonging to the genus Cytospora are a common cause of the "Die-Back" of fruit trees, including the apple, but in most cases the species has not been determined. *C. personata* has been recorded on the branches of *Pyrus Malus* (31) and by Él. and Ém. Marchal (24) on pear fruit.

We have obtained it once only, from an apple which was brown throughout with sterile stromata on the surface.

SPHAEROPSIS MALORUM Peck.

This fungus is well known in the United States as a cause of fruit decay, of canker and of leaf-spot. It also causes a canker in Australia. In 1910 Salmon reported the first occurrence in England as a canker of the pear tree, and more recently the Ministry of Agriculture (45) stated that it is fairly widely distributed as a leaf-spot.

Horne records it as a common rot-producing fungus on apples, but in our experience it is met with only rarely in store, having been found once on Stirling Castle and once on Bramley's Seedling. Duggar (13), who gives a good photograph of the rot, states that, though often observed, it is not serious as a fruit rot in the United States.

CONIOTHYRIUM CYDONIAE Brun.

Horne (17) described a variety *Mali* of this species on the apple, the distinguishing character being the zoned manner of growth. Our cultures do not show zonation and the morphological characters of the fungus are identical with those of the species. The genus Coniothyrium has not been recorded on the apple except by Horne.

ASCOCHYTA PIRINA Pegl.

The variable character of the septa in the spores of Ascochyta and related genera is well known (5) and the cultures we have obtained (once from Bismarck and once from Bramley's Seedling) always show a considerable proportion of non-septate spores. The morphological characters are identical with *Ascochyta pirina.*

This species has hitherto only been recorded on the leaves and fruit of the pear in North Italy.

DIPLODIA MALORUM Fuck.

Four species of Diplodia have been recorded on the apple tree, viz. *D. Malorum* Fuck. on the fruit, and *D. pseudodiplodia* Fuck., *D. maura* C. & Ell. and *D. piriformis* (Preuss) Sacc. on the branches. Of these the first three are very similar in character, so that it is difficult to be certain to which species our cultures belong. Provisionally they are assigned to *D. Malorum* Fuck. This species has been observed on decaying apples in Germany and Italy.

Only two isolations have been made in each case from dark brown rots at the stalk of the apple.

Artificial infections have not yet been carried out.

CYTOSPORINA LUDIBUNDA Sacc.

This fungus has been recorded in England on apples by Horne. It had been previously known on the branches of a number of trees though apparently not on Pyrus. The fungus does not grow well on synthetic media but spores readily on beer-wort agar. The rot is usually light brown with a definite margin; no fructification has been seen on the host. It arises at the stalk or at the calyx, rarely at a lenticel. The fungus was obtained twenty times during the season 1921–22.

MELANCONIEAE.

GLOEOSPORIUM ALBUM Osterw.

This has not been recorded before in England. It was first described in 1907 by Osterwalder (27) as attacking apples and pears in storage. Schneider-Orelli (33) described it as one of the most important rot-producing fungi and studied its growth under various

conditions of temperature. Él. and Ém. Marchal (24) described it as a common storage-rot fungus in Belgium. We have found it on both apples and pears, but it is one of the less frequent fungi. The rot produced is very characteristic. It is usually of lenticel origin, brown, with a definite, regular margin, the centre of the rot being sunken and paler than the rest, or the whole rot may have alternate light and dark brown zones. Acervuli develop later on which spores are ultimately produced. The fungus progresses relatively slowly both on the host and in culture.

G. FRUCTIGENUM Berk.

This fungus has only been isolated by us twice. The cause of a widespread disease in America and on the continent it is remarkable that it is not more prevalent in this country. It is generally supposed to cause damage in our stores. Schneider-Orelli (33) considered it of less importance in storage than *G. album*. Owing to the similarity of the descriptions of the rots it is probable that in this country rots caused by the latter fungus are often mistaken for Bitter Rot. Some of the Fusarium rots also are not unlike.

COLLETOTRICHUM GLOEOSPOROIDES Penz.

This fungus has only occurred once, but we have shown by inoculation experiments that it is capable of infecting the apple. *C. gloeosporoides* is a fungus very common on oranges. The form we isolated from apple agrees very closely with that we have isolated from oranges and it is interesting that Darnell-Smith (10) found that spores taken from Emperor mandarins could infect apples.

CORYNEUM MICROSTICTUM Berk. and Br. var. MALI, var. nov.

The fungus of the genus Coryneum isolated by us from rots of apples appears to agree closely with herbarium specimens of both *C. foliicolum* Fuck. and *C. microstictum* Berk. and Br. There would appear to be no well-marked differences between the two. Spore measurements are identical and diagnostic characters indicate that *C. foliicolum* usually possesses pointed olive-coloured spores, whereas in *C. microstictum* the spores are more usually rounded at the ends and honey-coloured. The spores of the fungus isolated by us have rounded ends and are distinctly olive.

C. microstictum is a widely distributed species. *C. foliicolum* is common in the orchards of America, occurring as a leaf-spot and also as a canker of apple trees. It has been shown by Lewis (23) to be capable of causing a rot of the fruit. *C. foliicolum* has been recorded in this country on apples, though only asso-

ciated with small spots and not active rots (18). The fungus isolated by us does not fructify on the apple and has been studied only in culture. In the absence of opportunity to make cultural studies of several species of Coryneum we have tentatively placed the species isolated by us as a variety of *C. microstictum* differing from the true form in the colour of the spores. We have shown by inoculation that it will cause a rot on the apple when penetration is brought about by injury of the surface cells.

PESTALOZZIA HARTIGII Tub.

Three species of Pestalozzia are recorded in Saccardo on Pyrus, *P. rostrata* Zab. on apple bark, *P. breviseta* Sacc. and *P. concentrica* B. & Br. on leaves of the pear. A fourth, *P. funerea*, has been isolated from the apple by Brooks and Cooley (2). Our fungus, which was only obtained once, has 3-septate conidia measuring $16–18 \times 6\mu$. It is therefore quite different from any of the above but closely resembles *P. Hartigii* previously only known on spruce in Central Europe.

Inoculations by the tube method failed, but on wounding, rots developed in each case which on isolation gave the original fungus.

HYPHOMYCETES.

OOSPORA MALI sp. nov.

Caespitulis rotundatis, albis; hyphis sterilibus repentibus; conidiophoris curtis, a mycelio haud distincta; catenulis conidiorum $50–150\mu$, conidiis hyalinis, ovoideis, $4–6 \times 3\mu$.

A new name is given provisionally to this species owing to the difficulty of identifying the species of this and allied genera from verbal descriptions. It is a fungus very common in spots at the lenticels of both Bismarck and Bramley's Seedling (off Chalk) during the season 1922–23. It has only once been isolated from a rot but not yet re-inoculated on to the apple. No species of Oospora have hitherto been recorded as occurring on the apple.

MONILIA FRUCTIGENA Pers.

Although this is generally considered an important rot-producing fungus in the store (43, 45), it would seem from the results of a systematic investigation of such rots that this is not so. Among all the isolations of rots on Bramley's Seedling during 1921–23 only two were infected with this species, and in the three varieties studied in 1922–23 none at all. These apples were all "late keepers." In earlier varieties such as Stirling Castle infection was greater but even then it was only responsible for 5–10 per cent. of the total rots. It usually appears shortly after storing and if affected apples are thrown

out it will not reappear; if left in, a few of the neighbouring apples may become contaminated. Spinks (37) gives an account of the characteristics of this rot on a large number of varieties. As an orchard parasite it is well known.

CEPHALOSPORIUM MALORUM nov. sp.

Effusum, albidum, hyphis hyalinis, conidiis ovato-ellipticis, hyalinis, $4\mu \times 2\mu$, ad apices ramulorum in capitula irregularia congestis.

This species appears to be very similar to *C. robustum* Preuss which has been described on apple wood though not on the fruit. The description of this latter species is very inadequate and it is not possible to establish the identity of the two. *C. Malorum* up to the present has always been isolated associated with other fungi.

HYALOPUS PRUINOSUS É. and É. March.

This is one of the less frequent weak parasites of the apple. Although inoculations have shown it to be capable of direct infection it is generally associated with the attack of other fungi under natural conditions. When the apple is artificially infected with *H. pruinosus*, a small, shallow rot, either light or dark brown, is produced. The Marchals (24) described it as occurring only on the pear.

HYALOPUS ALBIDUS sp. nov.

Caespitulis effusis; tenuissimis, albis; hyphis filiformibus, gracilibus; capitulis conidiorum globosis 20–40, conidiis oblongo-cylindraceis, $12–15 \times 3\mu$.

This species is readily distinguished from *H. pruinosus* in culture by its pure white growth. It resembles *Hyalopus Populi* Nijp. except that the latter has shorter spores ($8–11 \times 3\mu$). It has been isolated four times from lenticel spots and three times from small rots. Inoculation experiments have not yet been carried out.

PENICILLIUM EXPANSUM (Link) Thom.

This well-known species of Penicillium does extensive damage to apples in storage. It is one of the few fungi which spore on the apple, so that the chance of infection increases in the store in proportion to the increasing number of apples affected. Because of its wide distribution and because of the obvious loss that it causes this fungus has received considerable attention from investigators of apple rots but mainly in relation to its germination and growth at different temperatures, particularly low temperatures (2, 6, 43). It has often been regarded as entirely a wound parasite, but Zschokke (42) has shown that,

though it is incapable of penetrating the cuticle directly, it gains access to the flesh of the apple through wounds and also through the lenticel openings or gaps in the cuticle. Once it has penetrated the internal tissues it passes from cell to cell directly through the cell walls. In our own experience, an analysis of the mode of entry of the fungus in a large number of rots caused by *P. expansum* shows that in the greater number penetration has taken place through the calyx end, or by means of the broken-off stem, or by wounds such as insect punctures, and only rarely through a lenticel.

The rot is very characteristic. It is light brown with a watery appearance, circular, soft, smooth in the earlier stages, but often wrinkled concentrically near the margin. The internal tissue is watery, pale in colour, often with a distinct green tinge, the vascular tracts standing out as brown areas. Coremia may be formed early in the development of the rot and spores copiously produced.

* * * *

A number of other species of Penicillium have been isolated, and some of these have been identified for us by Dr Thom. They include *P. luteum* Zuk., *P. chrysogenum* Thom, *P. puberulum* Bainier, *P. rugulosum* Thom, and *P. stoloniferum* Thom. It is hoped, however, to give later a more comprehensive study of the Penicillia infecting apples in storage. Under some circumstances their attack assumes considerable importance.

Sporotrichum Malorum sp. nov.

Effusum, atro-griseum; hyphis intricato-ramosis, septatis, hyalinis, conidiis oblongis, hyalinis, 6–8 × 2–3μ.

The only other species of Sporotrichum recorded on apple fruit is *S. Thumenii* Sacc. (Pennsylvania); *S. Peckii* Sacc. occurs on apple wood. Both species, however, differ in the colour of the mycelium and in the size and shape of the spores.

The fungus has been isolated about thirty times. The rots are dark brown and rather dry and arise at a lenticel spot, insect wound, or at the calyx.

Cephalothecium roseum Corda.

This widely distributed fungus has generally been one of the fungi used when the temperature relations of apple rot fungi have been studied (2, 6, 33). Brooks, Cooley and Fisher consider it of little economic importance except in some areas where it may do great damage following scab. Horne states that it is a common rot-producer in cold storage in this country, but in our experience it is rare except under warm, moist conditions or on early, soft-skinned varieties. Inoculation experiments were carried out at

24° C., 15° C. and 8° C. At the highest temperature small rots were quickly formed, which on re-isolation gave *C. roseum*, but at 8° C. the fungus was unable to grow at all.

RAMULARIA MAGNUSIANA (Sacc.) Lind.

This fungus was formerly known as *Septocylindrium Magnusianum* Sacc. (25). The Marchals (24) found it on the pear, but it has not been found previously on the apple, its principal host being *Trientalis europaea*. The ascigerous stage was first found by Wollenweber on *Rubus fruticosus* and named *Neonectria Ramulariae*.

The conidia are cylindrical, obtuse, 1-septate (rarely continuous or 3-septate), 20–25 × 3·5–4·5 μ. The red perithecia also develop in our cultures but, up to the present, have remained sterile.

The fungus has been obtained once only on the variety Allington Pippin. The rot was large, dark brown, soft and rather shallow, with a definite margin. Its parasitism has not been established.

ZYGODESMUS FUSCUS Corda.

This fungus has only been isolated once from a rot on an apple off Fen soil. Species of Zygodesmus are now usually placed in the genus Hypochnus. The absence of the characteristic basidia from our cultures, however, and the close agreement with the original figure and diagnosis appear to warrant the retention of Corda's name. The fungus has been recorded several times in this country on decaying wood.

CLADOSPORIUM HERBARUM Pers.

Although often associated with other fungi in rots, and more commonly following superficial scald, *Cladosporium herbarum* is capable of direct infection of the apple. This has been confirmed by artificial inoculations. The attack progresses very slowly, the rot is brown to black, dry and shallow. As an independent parasite it is not of much importance.

A. S. and E. V. Horne (18) isolated *C. epiphyllum* Mart. from apple spots, but Brooks and Hansford (4) consider that this species is indistinguishable from *C. herbarum*.

STEMPHYLIUM GRAMINIS (Corda) Bon.

Mycelium black, hyphae dark, transparent; conidia dark brown, slightly warty, 15–36 × 15–18 μ, muriform with 1–3 transverse and one longitudinal septa.

The species closely resembles the description of *Soredospora graminis* Corda, with the exception of the "hyphis moniliformibus." The hyphae in our specimens are of the usual

Stemphylium type. Those drawn by Corda are quite anomalous for the genus and would appear to belong to some other species. Oudemans (28) considers that they are conidia of a species of Sporotrichum. This being so there would be little doubt that our species is *Stemphylium graminis*.

The fungus grows very well in artificial culture, having a characteristic black shiny appearance and producing abundant spores. It has only been isolated from lenticel spots but inoculation experiments have shown that it can be parasitic.

ALTERNARIA TENUIS Nees.

This is a common saprophyte and a weak parasite on many hosts. It has been shown by inoculation to be capable of infecting the apple through the lenticel but only if this has first been injured by ammonia vapour. The rot formed is smooth, dark brown with a definite but irregular margin.

Other species of Alternaria have been recorded on the apple fruit. A. S. and E. V. Horne (17, 18) record *A. Grossulariae* and *A. pomicola* Horne as occurring in spots. These differ from *A. tenuis* in size and shape of spores. Él. and Ém. Marchal (24) described the species they isolated from an apple rot as *A. tenuis* var. *Mali*, but as the fungus is so widely distributed and the differences are so slight it seems unnecessary to make this distinction. In America, Brooks, Cooley and Fisher (3) state that one or more species of Alternaria are commonly responsible for the rotting of apples but give no diagnostic characters of the species.

TILACHLIDIUM CINNABARINUM sp. nov.

Caespitulus cinnabarinus; stromatibus erectis, altitudine 5 mm. attingentibus, superne eleganter iterato ramosis, ramis extremis capitulum globosum, album, 20–40 μ diam. ferentibus; conidiis hyalinis, recte, cylindraceis, 5–8 $\times$ 2 μ.

Of the genus Tilachlidium only *T. Malorum* É. and É. March. has been found on the apple. It differs from this species in the orange colour of the synema, and the larger spores and capitula.

It is doubtful whether this fungus is capable of parasitising the apple directly—it has been obtained either from small spots at the lenticels or from rots having two or more fungi present. Artificial inoculations have not yet been carried out.

GRAPHIUM MALORUM nov. sp.

Stipitibus gregariis, teretibus, erectis, 5–10 mm., ex hyphis filiformibus, fuligineis constantibus, sursum non dilatatis; conidiophoris gracilibus, hyalinis; conidiis globosis, fuligineis, 3–4 μ diam.; capitula 10–20 μ diam.

This species has only been isolated once. It differs from *G. fructigenum* É. and É. March., the only species up to the present isolated from apples, in size and shape of spores. The latter are elliptical, 7–13 × 4μ.

TUBERCULARIA VULGARIS Tode.

The occurrence of this fungus is of special interest as its perithecial stage, *Nectria cinnabarina* Fr., is a common canker-producing fungus on apple trees. *Tubercularia vulgaris* has been recorded before on the fruit. It was obtained twice, forming a large pale brown rot with an indefinite margin.

Fusarium.

F. ARCUATUM Berk. and Curt.

This has not before been recorded on the fruit, but was first found on the bark of apple trees in North America. It is new to Great Britain.

In culture the conidia are copiously produced in effused cream or pale orange masses. They are 3–5-septate, 40–60 × 3–4μ in size. No blue sclerotia are formed.

The rot produced resembles that caused by *Fusarium fructigenum*, the apple ultimately becoming brown throughout; sometimes acervuli are formed.

Inoculation experiments have shown that it is capable of directly parasitising the apple.

F. ANTHOPHILUM (A. Braun) Wollenw.

This species is also new to Great Britain and has never previously been recorded on the apple. It occurs in Germany on the corolla of *Succisa pratensis*. We have met with it only once and have not yet proved that it is parasitic. It is nearly related to *F. avenaceum*, being distinguished by the pink colour of the plectenchymatous hyphae.

F. VITICOLA Thüm.

This species was discovered in 1878 on the vine (*Vitis vinifera*). It has been recorded on this host in England and on various other hosts in Europe but not hitherto on *Pyrus Malus*. It is a fairly common cause of rots in storage though much less important than *Fusarium fructigenum*.

The conidia are usually 3-septate, 36–40 × 3–4μ in orange masses. On Crabill's synthetic media copious mycelial growth and bright crimson coloration of the agar characterise the fungus. This crimson colour is soluble in alcohol and becomes greenish yellow with acid, violet with alkali. No sclerotia are ever formed.

The rot caused by *F. viticola* is similar to that due to *F. fructigenum.* The apple becomes brown throughout with tufts of white aerial hyphae on the surface. Inoculations of this fungus on the healthy apple have been successful in producing rots.

F. AVENACEUM (Fr.) Sacc.

Fusarium avenaceum has been recorded on various hosts but until Marchal recorded its occurrence on pear under the synonym *F. subulatum* App. & Wollenw. it was not known on any fruit. It is not of great importance in storage as we have met with it only twice. The long, slightly curved conidia measure 50–70 $\times$ 4μ and are 5–7-septate. On Crabill's medium the mycelium is floccose and a certain amount of crimson coloration is produced. Inoculations from single spore cultures have successfully produced rots.

F. FRUCTIGENUM Fr.

This is the most important species of the genus Fusarium occurring in apples in store.

The original description of *F. fructigenum* is incomplete, but in 1918 Wollenweber (40) emended the species and included in it both *F. Cydoniae* Allesch. and *F. Cydoniarum* Roum. He records its occurrence on a number of hosts in Europe and America but it has not before been identified in England.

The fungus grows readily on artificial media and forms blue-green sclerotia which are turned crimson with acid and blue or violet with alkali. Frequently also part of the agar is coloured green. The conidia are developed in bright orange masses; they are 3–7-, usually 5-septate, 30–45 $\times$ 3–4μ. Light has a pronounced effect on the growth. In many cases when the cultures are kept in the dark no spores are formed and no sclerotia, only the green colour in the agar appears; but if the culture is kept in the light the medium assumes a pink tint and spores are produced copiously. Even when a culture is able to produce spores in the dark, the spore masses are more copious and brighter in colour when formed in the light.

In an endeavour to trace the source of this infection we examined cultures from Bud-rot of apple blossom through the courtesy of Mr R. W. Marsh and found his culture identical with our species. "Bud-rot" appears to be a widely distributed disease and was first recorded in 1914 (44). Salmon and Wormald 1915 (32) described an unidentified species of Fusarium causing Eye-rot of the apple and their description also agrees closely with that of *Fusarium fructigenum.*

Although not always associated with the "eye" or calyx end of the apple this mode of entrance of the fungus is very characteristic in the store. The rot begins as a small brown circular area, the margin of which is definite and usually regular. After the whole of the apple has been permeated by the fungus white (sometimes yellowish) hyphae come to the surface through the lenticels, forming small tufts; later acervuli develop but these have not been seen to produce spores on the apple, although they do so on pears. The rot is firm in consistency and the diseased tissues are dry in texture.

Inoculation experiments have shown that *Fusarium fructigenum* is a vigorous parasite readily forming large rots at both 8° C. and 15° C.

F. CULMORUM (W. G. Sm.) Sacc.

This fungus was first described in this country in 1894 under the name of *Fusisporium culmorum* (36). It is more usually met with on cereals though it occurs on a variety of hosts. It was found by us causing a rot of an apple (Warner's King) while still on the tree. Inoculations from single spore culture on healthy apples have been successful.

F. MARTII App. and Wollenw.

Although isolated from apples only once it has been shown by inoculation to be capable of parasitising the fruit. Hitherto it has been recorded only on the potato and the leaves of *Pisum sativum*. Wollenweber includes *F. Coelogynes* P. Henn. in this species.

F. MARTII App. and Wollenw. var. VIRIDE Sherb.

This is distinguished in culture from the above by a characteristic green colour at the bottom of the slant in the case of Crabill's synthetic media. Artificial inoculations have shown the fungus to be parasitic on the apple.

CYLINDROCARPON MALI (Allesch.) Wollenw.

This fungus was formerly known as *Fusarium Mali* Allesch. but in 1913 it was placed by Wollenweber (40) in his new genus Cylindrocarpon. It is the conidial state of *Nectria galligena* Bres. and both stages have been found on branches of apple trees in Germany. The fungus has been isolated from apple rots in Belgium. The spores, which are formed in pale yellow masses, are 1–3-septate, obtuse, 20–45 × 3–4μ. It is rare on the apple, having been found by us only in a lenticel spot on Bismarck, and in a small brown rot on Bramley's Seedling. No inoculations to establish its parasitism have yet been made.

RAMULARIA HETERONEMA (Berk. and Br.) Wollenw.

Berkeley and Broome first described this fungus under the name of *Fusarium heteronema*. They obtained it from decaying pears, but it does not appear to have been found since in this country. It has been isolated by us from several varieties of apples on which it caused an ordinary brown rot, indistinguishable in any way. Inoculations have shown that it readily infects Bramley's Seedling.

On Crabill's synthetic media its appearance is very characteristic. The spores are developed on large sporodochia in sulphur yellow masses and the medium takes on a slight orange coloration. The spores are oblong, obtuse, slightly curved, 3–5-septate, 36–60 × 3–5 μ.

In conclusion we wish to record our indebtedness to Dr H. W. Wollenweber for the identification of the Fusaria and allied genera, and to take this opportunity of thanking him for his help with this difficult group. We have much pleasure also in thanking Dr C. Thom, for examining some of our Penicillia species; Professor Marchal, Professor Chupp, Dr J. W. Roberts and Miss Gilchrist for sending us cultures for purposes of comparison; Mr J. Ramsbottom for examining some of the cultures now described as new and finally Mr F. T. Brooks for criticism and advice.

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EXPLANATION OF PLATES VI AND VII.

Plate VI.

Fig. 1. *Polyopeus purpureus* v. *verus* on Stirling Castle.
Fig. 2. *Diaporthe perniciosa* on Bramley's Seedling.

Plate VII.

Figs. 1–5. A series of sections through a stroma of *Phomopsis Mali*, isolated from an apple and growing in culture. In 1 and 2 several cavities are visible in the stroma, but in other sections through the same stroma they can be traced to belong to one irregular cavity.

1
2
5
3
4

THE CAUSE OF CITRUS SCAB.

(With Text-fig.)

By E. M. Doidge, Assistant Chief, Division of Botany, Pretoria, and E. J. Butler, Director, Imperial Bureau of Mycology, Kew.

It is now well known that the disease called scab or verrucosis of the lemon is not caused by *Cladosporium Citri* Massee as originally believed, but by another fungus which has been described as the causal organism by Fawcett*, Winston†, and others, but not named as its mycological position was not determined.

Scab is a common disease in rough lemons in the more humid parts of South Africa and the organism which produces it has been isolated a number of times during the past three years. Inoculations with a pure culture of this organism have invariably produced typical scabs on young lemon shoots kept in a humid atmosphere. Its cultural characters agree with those so fully described by previous workers, especially Winston; and the formation of true conidia, enabling the systematic position of the organism to be determined, has now been obtained.

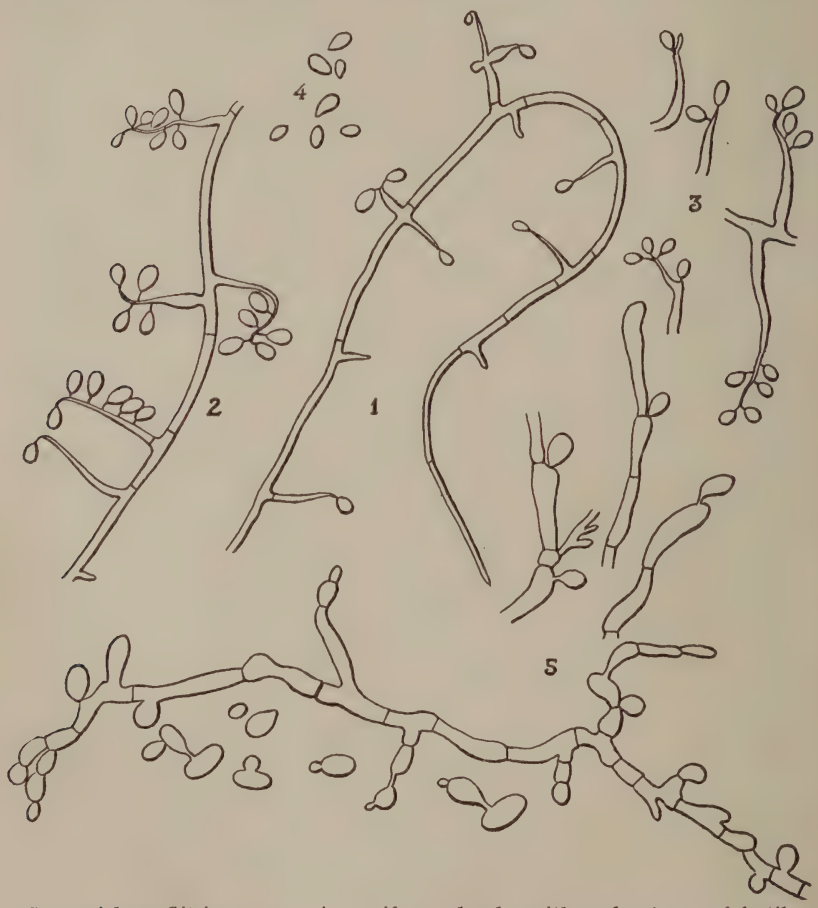
The hyphae are of two kinds: (1) immersed or stromatic, conspicuously septate, often toruloid, up to 3 or 4 μ in diameter; and (2) superficial, creeping, obscurely septate, 1·5 to 2 μ thick, and uniform. The true conidia have been found only on the latter, terminally or on short, lateral, usually unbranched hyphae (Fig. 1). They are formed terminally on the narrowed end of the hypha, but the latter continues growth by a very fine branch arising a short distance below the apex (Fig. 3), so that the terminal spore and its stalk are pushed over to a lateral position. By the rapid repetition of this process small, elongated "heads" (Figs. 2 and 3) of conidia are formed, one (the youngest) being always terminal, and the others attached to lateral stalks. The conidia (Fig. 4) are hyaline, unicellular, oval, sometimes slightly narrowed at the basal end, and measure 2–6·5 × 1·3–2 μ, mostly 3–4 × 1·5–2 μ.

On the immersed hyphae (Fig. 5) lateral, bud-like branches are often formed, which readily become detached and continue to grow by a process of very irregular budding, mixed with the development of short hyphae. These bodies, which have been

* Fawcett, H. S. Citrus Scab. Florida Agric. Exper. Stat. Bull. 109. 1912.
† Winston, J. R. Citrus Scab: its cause and control. U.S. Dept. of Agric. Bull. 1118. 1923.

described by previous observers, are probably of an oidial or chlamydospore nature and are not true conidia.

The fungus can be most satisfactorily placed in the form-genus *Sporotrichum*, amongst the heterogeneous elements of which it most closely resembles the animal pathogens. This resemblance is apparent not only in the spore characters but



Sporotrichum Citri n. sp. 1. A sporiferous hypha with early stages of fertile branches. 2. A hypha with well-developed conidial heads. 3. Stages in the formation of the conidial heads. The upper figure shows renewed growth taking place a little below the conidium. 4. Conidia. 5. Immersed hyphae with bud-like detachable segments, and some of the latter germinating. All ×900.

also in the peculiar growth in culture, especially the raised, convoluted colonies, sometimes with an outgrowth of spiny synnemata, and the marked colour changes on different media. The pleomorphism of the human pathogen *S. Schenckii* (*S.*

Beurmanni) is fully described by Davis*, and this paper, together with De Beurmann and Gougerot's monograph of the pathogenic species of the genus†, will serve to make the suggested relationship more clear. The specific name *Citri* is proposed (though the same or a closely allied species attacks the avocado pear), chiefly because the scab fungus has been so often referred to as *Cladosporium Citri* even after it was known that it was not a *Cladosporium* and was not the same as Massee's species. The following diagnosis has been drawn up from cultures.

Sporotrichum Citri Butl. n. sp. Mycelio superficiali ex hyphis repentibus, tenuibus, 1·5–2μ cr., obscure septatis, hyalinis, composito; conidiis parcis, initio acrogenis, solitariis, dein acropleurogenis, spiculas subcylindricas in ramis lateralibus mycelii formantibus, distincte pedicellatis, hyalinis, ovalibus, basi subattenuatis, 2–6·5 × 1·3–2μ (saepius 3–4 × 1·5–2μ); mycelio immerso ex hyphis copiose septatis, 3–4μ cr., irregulariter toruloso-ramosis, hinc inde ramulos ellipsoideos, facile desciduos ac conidia simulantes gerentibus (?chlamydosporos), composito.

In foliis, fructibus, ramulisque vivis Citri.

NOTE ON THE ASSOCIATION OF TILLETIA TRITICI WITH "EPILEPTIFORM CONVULSIONS" IN THE DOG.

By J. Russell Greig, M.R.C.V.S., Professor of Medicine, Royal (Dick) Veterinary College, Edinburgh.

ALTHOUGH convulsions of an epileptiform character are commonly met with in the dog, their association with spores of fungi has not, so far as I know, been recorded.

Recently three cases, showing epileptiform symptoms, which appeared to be associated with the spores of *Tilletia Tritici*, were admitted to the hospital of the Royal (Dick) Veterinary College. The symptoms were identical in each case. The animal was suddenly attacked by a series of convulsions, which continued for some hours, and terminated in coma; in two cases death resulted, but in the other case recovery took place, though the animal was subsequently destroyed. As a routine measure the faeces in such cases are examined for the presence of Ascarid eggs, and in case A, although no eggs of parasites were found, the faeces contained very large numbers of spores, which proved to be those of *Tilletia Tritici*. An examination of the abdominal organs was made *post mortem*, but no definite abnormality was

* Davis, D. J. The identity of American and French Sporotrichosis. Univ. of Wisconsin Studies in Science, II, pp. 104–130. 1921.

† Les Sporotrichoses. Paris, 1912.

found. In case B the faeces contained large numbers of the spores, which were found on *post mortem* to be present throughout the alimentary tract; they were also very numerous in the bile and urine, which in this case were examined microscopically. The brain unfortunately was not examined, and no definite macroscopic lesion was discovered in any other organ.

In case C, spores were present in large numbers in the intestine and urine. No definite lesion was remarked until the cranium was opened, when an acute cerebral meningitis was observed; smear preparations from the cerebral cortex again revealed the presence of the spores. In sections cut from brain, kidney, liver and spleen the blood vessels were seen to contain very large numbers of dark pigmented bodies; these showed much variation in size, ranging from mere particles of pigment to bodies 12μ in diameter; their nature is yet to be determined. Since the spores were so numerous in the urine it was expected that they might also be present in the blood stream. No spores have, however, been seen in sections of tissue containing blood vessels, and it is possible that these pigmented bodies may represent spores in a state of disintegration; on the other hand, they may be mere artefacts. Other workers have shown by feeding experiments that the spores of *Tilletia Tritici* are capable of being absorbed by the intestines and reaching such organs as kidney and liver; in one case the spores were found to have actually penetrated the placental membranes of a pregnant bitch. How an inert body, measuring about 18μ in diameter, is capable of such absorption and penetration presents an interesting problem.

Mr D. L. McWhirter, B.Sc., M.R.C.V.S., who has assisted me in the investigation, has examined the faeces of a number of healthy dogs and found that, although the spores of *Tilletia* are frequently present, they are by no means numerous. In many cases lengthy search was required before a single spore could be demonstrated, whereas in the faeces of affected cases commonly six and not infrequently twelve spores could be seen in a single field. *Tilletia Tritici* is a normal parasite of wheat, and since wheat straw is commonly used for bedding it is possible that this is the medium of infection.

Although our material is still insufficient to permit of our arriving at any definite conclusion, it appears probable that on occasion the spores of *Tilletia Tritici* may constitute a factor in the production of "epileptiform convulsions."

Further investigations are in progress, and it is hoped that a fuller report may be made later.

I have to thank Dr Malcolm Wilson, of Edinburgh University, who kindly identified the spores.

A NEW DISEASE OF THE GRAMINEAE: PLEOSPHAERIA SEMENIPERDA nov. sp.

(With Plates VIII and IX.)

By C. C. Brittlebank, Vegetable Pathologist, and D. B. Adam, Assistant, Department of Agriculture, Victoria.

OVER a number of seasons "Take-all" is probably the most serious disease of wheat in Australia. It is difficult, however, to prove such a statement with figures as no survey or estimate of real accuracy has ever been made of the losses from the various cereal diseases in this country.

The name "Take-all" as applied to a specific disease, while undoubtedly strikingly apt, as such, necessarily covers a wide range of different plant conditions when used as a descriptive term for a disease. On this account, perhaps, it is not so fortunate, since, in fact, several fungi do produce the general symptoms of the true "Take-all" disease. The term, while it may not have led to a confusion of the various fungi concerned, certainly has led to an awkward vernacular nomenclature. Thus we find reference in the literature of this subject to the true "Take-all" disease and to the "so-called Take-all disease" of Illinois and Indiana—diseases which are now recognised as being caused by different organisms.

It is worthy of note that while *Ophiobolus cariceti* (Berk. and Br.) Sacc. (1) is the fungus most generally associated with the "Take-all" disease of wheat, records of its occurrence on oats are rare (2); particularly is this so in Australia.

In 1919, an outbreak described as "Take-all" disease was reported from Hopetoun, Victoria. Oats and wheat were both reported to be badly affected. Subsequent examination showed that it was not the true "Take-all" disease and that the same fungus was present in the diseased plants of both crops.

The plants were evidently affected while still young, many plants having died before they had tillered. The surviving wheat plants were stunted, the leaves were coloured yellow, turning brown towards the tips. The oat plants surviving were also stunted, the leaves were upright, narrow and either red or streaked with red.

The affected areas in both crops were roughly circular, from one foot to five yards in diameter. Affected plants are about one-third the height of normal plants. These diseased plants do not recover.

Affected plants were carefully removed and examination showed that the original seed had been destroyed by a fungus. Out of the diseased seeds, long, dark, parenchymatous synne-

mata protruded, from which arose numerous septate condiophores, bearing at their tips multiseptate conidia, either singly, or in a single whorl of from 3–7 spores (Fig. 1). A brown septate mycelium had also grown along the roots and about the base of the stem. Some of the hyphae bore conidia directly. The roots were injured about their bases.

A number of pure cultures of this fungus were obtained on a variety of culture media, including oat meal, wheat meal, starch, potato and nutrient agar. Each medium, with the exception of nutrient agar, gave similar growths, though of variable vigour. On nutrient agar the mycelium was at first hyaline but later turned a sooty brown. From the mature strands, septate conidiophores arose, the upper three cells of which were darker in colour than the rest. These conidiophores bore from 1–7 conidia (Fig. 3). Occasionally conidia were also borne directly on the mature mycelium.

The conidia were brown, slightly spindle-shaped, 3–10-septate, straight or very slightly curved, and rounded at the ends, the end cells being slightly lighter coloured than the rest, 75–110 $\times$ 12–18μ (Fig. 2). On oat and on wheat agar the mycelium was at first hyaline but subsequently became brown, and bore straight or slightly curved, 5–10-septate conidiophores, 220–350 $\times$ 7–9μ; the apical cells were dilute honey-brown to hyaline and bore typical conidia. From the centre of the cultures black to dark brown synnemata, varying in dimensions from 2–9 mm. $\times$ ·5 mm. arose, either single or branched, straight or curved, parenchymatous, cylindrical but tapering towards a lighter coloured apex. At first the synnemata were smooth but later were beset with conidiophores bearing typical conidia. At the base of the synnemata numerous pycnidia were formed which were solitary or gregarious, parenchymatous, greenish brown by transmitted light, 450–495μ in diameter, papillate, setulose, with simple setae which were straight or curved, continuous to 3-septate, tapering towards the apex, brown at the base, the colour diluting towards the tips, 150–170 $\times$ 5μ (Fig. 4).

The pycnospores were irregularly fusoid, continuous, hyaline or honey-brown in mass, 8–12 $\times$ 2μ. The pycnidial stage has never been encountered in natural infections, though it develops on inoculated wheat grains.

Perithecia also developed on these cultures and upon sterilised seeds of *Triticum sativum* Lam., *Avena fatua* L., and *Bromus sterilis*, L., all of which had been inoculated with conidia from a pure culture of the fungus. The perithecia were black, 650–680 $\times$ 250–500μ, with narrowed or shortly stalked base, densely hirsute, with bristles 350–380 $\times$ 10–12μ, straight or slightly curved, and tapering, 7–10-septate, some of the bristles functioning as conidiophores and bearing conidia at their

slightly swollen tips (Fig. 5). The asci were cylindrical, rounded at the apex, 450–580 × 30–35 μ, paraphysate, with filiform paraphyses, slightly longer than the asci. The asci were obliquely uniseriate, with muriform, yellowish brown, 7- rarely 8-septate ascopores, slightly constricted at all septa but most definitely at the medium septum (Fig. 6).

A large number of experiments were carried out to ascertain whether the fungus isolated on the culture media was responsible for the injury observed in oat and wheat plants at Hopetoun. Soil was sterilised by heating to 120° C. in an autoclave on three successive days. Wheat and oats "pickled" in 1 per cent. copper sulphate for three minutes, removed and washed three times with sterile water, were infected with conidia from a pure culture. Inoculation was effected by bringing the seed into contact with a spore cluster. The seeds were planted immediately in the sterilised soil and then covered with bell-jars. Check plants were grown under similar conditions except that the seeds were not infected with spores. Seedlings appeared from all seeds planted.

After twenty-nine days a marked difference in growth was noted between the inoculated plants and those in the check pots. The infected plants were stunted and weak, and similar in appearance to the original diseased plants. Close examination revealed typical mycelia, with synnemata bearing conidia, arising from the diseased grains. The bases of the roots were also injured. These experiments were repeated many times with similar results. Wheat seed was also successfully inoculated. Some grains were sterilised by being placed in 1–1000 mercuric chloride for ten minutes, washed three times in sterile water and infected with conidia by being placed in contact with a pure culture. The seeds were placed in a sterilised, plugged test-tube and removed to a cool place. Within ten days after inoculation dark pustules were noted beneath the pericarp. Five days later, the pericarp ruptured: after thirty days synnemata bearing conidia developed (Fig. 7): later still pycnidia and perithecia were produced. These were similar to those produced on the various culture media.

The suggestion that this fungus was the cause of the disease at Hopetoun was considered established.

This fungus, considering the Ascomycetous form, undoubtedly belongs to the genus *Pleosphaeria* Speg. (3).

The description of the conidial form agrees closely with *Podosporiella verticillata* described by P. J. O'Gara, with which we think the subject of the present study is identical. This fungus is represented as being the cause of a disease of germinating wheat in Salt Lake Valley, Utah, U.S.A. in the summer of 1915 (4).

The occurrence of conidia on conidiophores borne directly on the mycelium, and not only on synnemata, both in the natural infections and on the different culture media, however, was not recorded by O'Gara.

Again, while agreeing with him that the fungus is mainly harmful in that it destroys the endosperm, which should go to the nutrition of the embryo, we do not agree that it is entirely non-parasitic, in view of the observed injuries to the base of the roots and also to the fact that plants in more advanced stages, when they are independent of the original seed as a source of food supply, apparently succumb to the disease.

E. H. Smith (Berkeley, California, U.S.A.), in a communication, forwarded a sample of a sterile fungus isolated by him from Australian wheat. An examination revealed *Podosporiella*-like synnemata and conidiophores, but no conidia. The culture plate was thin, and we think had dried out before the fungus had produced conidia. O'Gara also noted this tendency to dry out as being a condition necessary to guard against, in order to get typical fructifications.

The perfect stage, *Pleosphaeria semeniperda*, was first observed as occurring on wild oats, *Avena fatua*, collected in 1898 by G. H. Robinson at Ardmona, Victoria. D. MacAlpine examined these specimens and assigned the name, *Pleosphaeria semeniperda*. However, such a species has neither been recorded, nor described anywhere to our knowledge: hence the present record and descriptions. The first specimen of the disease on wheat was obtained from a milling sample forwarded by Mr P. R. Scott (1913).

Further records of occurrences on different hosts are:

Bromus sterilis L. at Myrniong, Victoria, Coll. C. C. Brittlebank (1899).

Avena sativa L. at Hopetoun, Victoria, Coll. A. E. V. Richardson (1919).

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(3) Spegazzini, C. Fung. Argent. iv. Anal. Soc. Cient. Argentina, xii, p. 65. 1881.

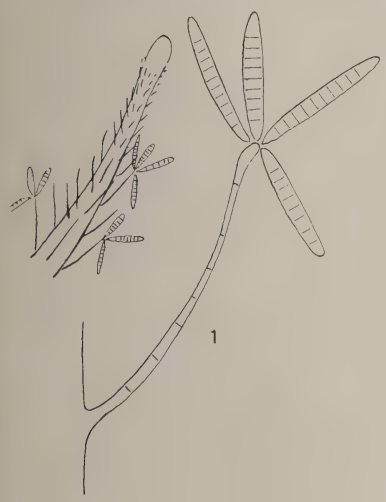
(4) O'Gara, P. J. A *Podosporiella* disease of germinating wheat. Phytopath. v, p. 323. 1915.

EXPLANATION OF PLATES VIII AND IX.

Fig. 1. Synnemata, conidiophores and conidia of the *Podosporiella* stage of the fungus (enlarged).

Fig. 2. Conidia. × 1000.

Fig. 3. Types of conidia and conidiophores not borne on synnemata, found both in natural infections, and on culture media. × 500.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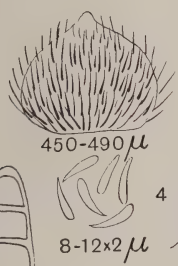
450-490 μ
8-12×2 μ
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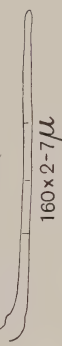
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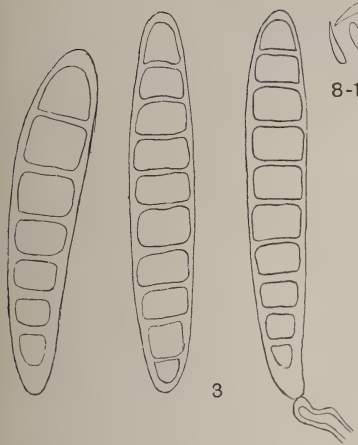
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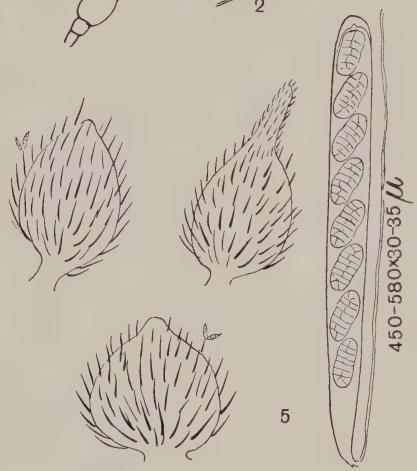
450-580×30-35 μ
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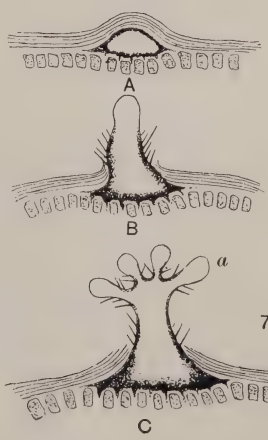
A
B
a
7
C

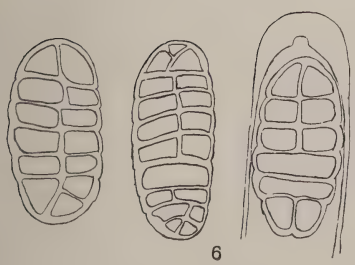
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Fig. 8.

Fig. 9.

Fig. 4. Pycnidium with pycnospores and seta, from growth on artificial media, pycnidium × 75, seta × 500, spores × 1000.
Fig. 5. Perithecia, ascus and ascospores from growth on artificially infected wheat grain, perithecia × 75, ascus × 300.
Fig. 6. Head of ascus with ascospores. × 1000.
Fig. 7. Development of synnemata in an infected wheat grain, *B* a simple synnema, *C* a compound form, with young synnemata developing (*a*).
Fig. 8. Fertile synnemata produced on artificially infected grains.
Fig. 9. Development of fungus under epidermis.

NOTE.

A DISEASE OF NARCISSUS BULBS CAUSED BY A SCLEROTIUM-PRODUCING FUNGUS.

During the summer of 1922 Narcissus bulbs were sent to the Pathological Laboratory attacked by one or other of several troubles, the most frequent being the disease caused by eelworm. Amongst these bulbs, however, were some in which no eelworm could be found, but minute, black sclerotia were present, mainly in the outer, thin papery bulb scales, less abundantly in the next following thicker, fleshy scales, and in some cases they could be found in the innermost scales, *i.e.* in the foliage leaf bases. Rather noticeable white mycelium was also present on the fresh bulbs, especially between the scales, but this became less obvious as the bulbs dried off.

Cultures were made both from the mycelium and from the sclerotia in July, and in October (Scilly Isles) and December 1922 (Barr's bulbs) from the sclerotia alone. The fungus grew readily on both potato- and oat-agar and sclerotia were produced in great abundance in all the cultures irrespective of their source of origin. The cultures became quite black in appearance owing to the multitude of sclerotia produced throughout the media. These sclerotia are readily seen with a hand-lens. They vary considerably in size, but their diameter averages about 0·1 mm. Mycelium is not conspicuous in the cultures on the two media employed. No form of fructification appeared in any of the cultures, but micro-conidia occurred.

The fungus recalls in a general way that causing a disease of rice, *Sclerotium Oryzae* Catt. first described from Italy.

On January 15th, 1923, five healthy Narcissus bulbs were planted in pots of ordinary soil. These were inoculated by placing portions of an agar culture of the fungus on the unwounded apex of each bulb. The bulbs were afterwards covered with soil. A control uninoculated pot of Narcissus was grown beside them. The bulbs produced foliage in due course, that in the control pot being normal, healthy and superior to that in the other pot. On March 15th the two sets of Narcissus plants

were taken up and examined. Of the five inoculated bulbs, all had taken the infection and small sclerotia had already been produced in their scales. Four bulbs had not flowered, as the bud had died, and all were poor in growth; the fifth bulb produced one small flower. The fungus was isolated again from the bulbs and grew readily in culture.

In the control pot, all the bulbs were healthy, with no trace of sclerotia; the plants were well grown and had flowered.

This trial indicates that the fungus is a weak parasite.

During the spring and summer of 1923 Narcissi in various stages of growth with similar sclerotia on the bulbs were received on numerous occasions from the Scilly Isles (May to August), and the fungus was also found among Narcissus bulbs from various growers and salesmen received from other sources.

N. L. ALCOCK.

PROCEEDINGS, 1924.

MEETING. UNIVERSITY COLLEGE, LONDON. *19th January.*

Mr W. J. Dowson. *Sclerotinia sclerotiorum* affecting *Antirrhinum via* the stigma.
Major K. W. Braid. Some observations on "Stag-headed" oaks.
Miss G. Lister. A collection of Mycetozoa from Northern India.
Mr F. Howarth. Sexuality of *Ustilago*.
Mr T. A. Sprague. The principles of Nomenclature.

MEETING. UNIVERSITY COLLEGE, LONDON. *15th March.*

Miss E. J. Welsford. Diseases of Cloves in Zanzibar.
Miss M. Brett. Sclerotia formation in a species of *Sterigmatocystis*.
Dr J. Peklo. The work of Kruis and Šatava on the life-histories of yeasts.
Mr A. D. Cotton. Some notes on the Ministry of Agriculture's Plant-Disease Survey.
Mr E. Clement. A preliminary account of the germination of *Odontoglossum* and other orchid seed without fungal aid.

SPRING FORAY FOR LONDON STUDENTS. *3rd May.*

Visit to Byfleet.

SPRING FORAY, MATLOCK. *16th—20th May.*

The whole of the first part of *The British Mycological Society's Transactions* (Season 1896–1897) and of the 1917 part have now been sold.

The other parts may be purchased at the following prices:—

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THE MATLOCK FORAY.

May 16th to 20th, 1924.

By E. M. Wakefield, M.A., F.L.S.

THE party which assembled at the Chatsworth Hydro on the evening of May 16th was not a large one, but numbers were reinforced next day by various members and visitors who were staying elsewhere.

On Saturday morning a full charabanc load started at 10 o'clock for Dovedale.

The valley was entered at Alsop-en-le-Dale, and worked as far as Thorpe, which was reached in time for tea. The scenery of Dovedale was much enjoyed, but the locality proved not very productive of fungi. At the outset abundant material of *Uromyces Ficariae* and the aecidial stage of *Uromyces Poae* was found on *Ranunculus Ficaria* growing on damp ground near the stream. In the same spot some fallen willows yielded fine specimens of *Ocellaria aurea*. The day's finds consisted for the most part of such microfungi—the larger forms being very few and far between. *Mitrophora hybrida* and *Disciotis venosa* were the most interesting of the larger fungi found.

After dinner in the evening Professor Kawagoe, a visitor, gave a most interesting talk on some Japanese fungi. In the first place he dealt in detail with the edible species, especially Shiitake (*Cortinellus Shiitake*) and Matsudake (*Cortinellus edodes*), describing their characteristics and the method of cultivation. He pointed out that Matsudake always grows in association with *Pinus densiflora* (or rarely *Tsuga japonica*), whereas Shiitake is characteristic of woods composed of Fagaceae (*Quercus, Fagus, Castanea*, etc.). The latter species is dried, and is in fact better dried than fresh. In the dried state it is exported to China.

Following this Professor Kawagoe added some notes as to some of the more important injurious fungi, notably those parasitic on the rice plant. At the close, after some interesting discussion, a hearty vote of thanks was accorded to Professor Kawagoe.

On Sunday the excursion chosen by all members present was to the Via Gellia, near Cromford. Here were very steep woods on either side of the road for a mile or two, and some hours were spent exploring these. As might have been expected, the slopes yielded little, and members soon found that it was more profitable to keep to lower ground close to the stream. Here *Urocystis Anemones* and *Plasmopara pygmaea* were found on

Anemone nemorosa, and *Peronospora Schleideni* on garlic. On some submerged twigs, etc., Mr R. W. Marsh found *Apostemidium Guernisaci*.

In the evening a short business meeting was held, instead of on the Monday, owing to the fact that many of the party were leaving the following day.

For the 1925 Spring Foray Tintern was proposed by Mr Rea and seconded by Dr W. Elliott. The date was to be arranged if possible in the Easter vacation.

Two new members were elected, and the meeting closed with hearty votes of thanks to Mr R. W. Butcher, who had made the arrangements for the various excursions, and to the landowners who had permitted their ground to be worked. Mr Cheesman then gave a talk on Polyporaceae, illustrated by numerous specimens.

The excursion on the Monday was to Alderwasley, lying between Whatstandwell and Ambergate. The party divided into two, one section going on to Ambergate at once, while the other alighted at Whatstandwell and worked back through the woods to Ambergate, where both sections united for tea. This ground appeared the most promising yet seen, but the day was marred by rain, which towards tea-time became very heavy and made most people hurry for shelter.

Several interesting Agarics were found on this day, such as *Entoloma clypeatum*, *Psilocybe bullacea* and *Pleurotus septicus*. Some very fine specimens of *Mitrophora hybrida* were secured, and a fir wood yielded abundant material of *Marasmius* (= *Collybia*) *esculentus*, as well as various microfungi on the fallen cones.

A complete list of the fungi gathered is appended, for assistance in compiling which the Secretary is indebted to all the members present, and especially to Mr Ramsbottom, Mr Rea and Mr Buddin.

Complete List of Species gathered during the Foray.

D. = Dovedale; *G.* = Via Gellia; *A.* = Alderwasley.

BASIDIOMYCETES.

Armillaria mellea (Vahl.) Fr., *D.*, *G.* (*rhizomorphs only*).
Mycena ammoniaca Fr., *D.*
Marasmius esculentus (Wulf.) Karst., *A.*
Pleurotus septicus Fr., *A.*
Pluteus cervinus (Schaeff.) Fr., *G.*, *A.*
Entoloma clypeatum (Linn.) Fr., *A.*
Pholiota mutabilis (Schaeff.) Fr., *D.*, *G.*, *A.*, marginata (Batsch) Fr., *D.*, *A.*, togularis (Bull.) Fr., *A.*
Galera tenera (Schaeff.) Fr., *D.*, hypnorum (Schrank) Fr., *D.*, *G.*, *A.*
Stropharia semiglobata (Batsch) Fr., *A.*
Hypholoma fasciculare (Huds.) Fr., *G.*, *A.*, sublateritium (Schaeff.) Fr., *A.*, appendiculatum (Bull.) Fr., *D.*

Panaeolus sphinctrinus Fr., *A*.
Psilocybe bullacea (Bull.) Fr., *A*., foenisecii (Pers.) Fr., *G*.
Polyporus squamosus (Huds.) Fr., *Matlock*, adustus (Willd.) Fr., *D*., *A*., betulinus (Bull.) Fr., *A*.
Fomes ferruginosus (Schrad.) Massee, *D*., annosus Fr., *A*.
Polystictus versicolor (Linn.) Fr., *G*., *A*.
Poria hymenocystis B. & Br., *A*.
Daedalea quercina (Linn.) Fr., *A*.
Irpex obliquus (Schrad.) Fr., *D*., *A*.
Odontia farinacea (Pers.) Bres., *A*.
Stereum spadiceum Fr., *A*., rugosum (Pers.) Fr., *D*., *G*., *A*., sanguinolentum (A. & S.) Fr., *A*., hirsutum (Willd.) Fr., *A*.
Hymenochaete tabacina (Sow.) Lév., *A*., corrugata (Fr.) Lév., *D*., *G*.
Corticium laeve (Pers.) Fr., *G*., Sambuci (Pers.) Fr., *D*., subcoronatum v. H. & Litsch., *A*., confluens Fr., *A*., porosum B. & C., *G*., *A*.
Peniophora cremea Bres., *D*., *A*., hydnoides C. & M., *D*., incarnata (Pers.) Cke., *G*., cinerea (Fr.) Cke., *D*., *G*.
Coniophora puteana (Schum.) Karst., *G*.
Solenia anomala (Pers.) Fr., *A*.
Tremella frondosa Fr., *G*.
Exidia glandulosa (Bull.) Fr., *D*.
Dacryomyces deliquescens (Bull.) Duby, *D*., *A*.
Sphaerobolus stellatus (Tode) Pers., *A*.

UREDINEAE.

Uromyces Ficariae (Schum.) Lév., *D*., *G*., *A*., Alchemillae (Pers.) Lév., *D*., Valerianae (Schum.) Fuck., *D*., Poae Rabenh., *D*., *G*. (*Aecidium*).
Puccinia fusca (Relh.) Wint., *G*., Violae (Schum.) DC., *D*., Saxifragae Schlecht., *D*., Adoxae Hedw. fil., *D*., *G*., Chondrillae Corda, *D*., Lapsanae (Schultz) Fuck., *D*., Menthae Pers., *D*., Magnusiana Koern., *A*., Poarum Niels., *A*.
Phragmidium Fragariastri (DC.) Schroet., *D*., Sanguisorbae (DC.) Schroet., *D*., subcorticium (Schrank) Wint., *D*.
Melampsora Rostrupii Wagn., *D*. (*Aecidium*).

USTILAGINEAE.

Ustilago violacea (Pers.) Wint., *D*., *G*., *A*.
Urocystis Anemones (Pers.) Wint., *D*., *G*., Violae (Sow.) Schroet., *D*.

PYRENOMYCETES.

Nectria cinnabarina (Tode) Fr., *G*., *A*., galligena Bres., *A*.
Ceratostomella pilifera Wint., *A*.
Rosellinia aquila (Fr.) de Not., *D*.
Melanomma pulvis-pyrius (Pers.) Fuck., *A*.
Stigmatea Robertiani Fr., *D*.
Leptosphaeria acuta (Moug. & Nestl.) Karst., *D*., *G*., *A*.
Melanconis stilbostoma (Fr.) Tul., *D*., *G*., *A*.
Eutypa Acharii Tul., *G*., flavo-virens Tul., *D*.
Diatrype Stigma (Hoffm.) de Not., *D*.
Diatrypella quercina (Pers.) Nke., *D*.
Cryptosphaeria eunomia (Fr.) Fuck., *D*., *G*.
Diaporthe salicella (Fr.) Sacc., *G*.
Xylaria Hypoxylon (Linn.) Grev., *D*., *G*.
Hypoxylon multiforme Fr., *A*.
Phyllachora graminis (Pers.) Fuck., *D*.
Endodothella Junci (Fr.) Theiss. & Syd., *A*.
Dichaena quercina (Pers.) Fr., *A*.
Rhopographus Pteridis (Sow.) Wint., *A*.
Aulographum vagum Desm., *A*.

DISCOMYCETES.

Mitrophora hybrida (Sow.) Boud., *D*., *G*., *A*.
Disciotis venosa (Pers.) Boud., *D*., *G*.

Cheilymenia stercorea (Pers.) Boud., *D.*
Coprobia granulata (Bull.) Boud., *D.*
Apostemidium Guernisaci (Cr.) Boud., *G.*
Polydesmia pruinosa (B. & Br.) Boud., *A.*
Calloria fusarioides (Berk.) Fr., *D.*
Orbilia xanthostigma Fr., *A.*
Chlorosplenium aeruginosum (Oeder.) de Not., *G.* (*mycelium only*).
Helotium herbarum (Pers.) Fr., *G.*, *A.*, cyathoideum (Bull.) Karst., *D.*
Dasyscypha virginea (Batsch) Fuck., *D.*, *A.*
Trichoscypha calycina (Schum.) Boud., *D.*, *G.*, *A.*
Hyaloscypha hyalina (Pers.) Boud., *G.*, *A.*
Micropodia aspidiicola (B. & Br.) Boud., *A.*
Mollisia cinerea (Batsch) Karst., *D.*, *G.*, *A.*, atrata (Pers.) Karst., *A.*, lignicola Phill., *A.*, fusca (Schum.) Karst., *D.*
Ocellaria aurea Tul., *D.*
Phacidium multivalve (DC.) Kunze & Schum., *A.*
Rhytisma acerinum (Pers.) Fr., *G.*

PHYCOMYCETES.

Plasmopara nivea (Ung.) Schroet., *G.*, pygmaea (Ung.) Schroet., *G.*, *A.*
Peronospora parasitica (Pers.) Tul., *D.*, Schleideni Unger, *G.*

FUNGI IMPERFECTI.

Phoma Urticae Schulz. & Sacc., *A.*
Macrophoma Fraxini Delacr., *G.*
Phomopsis Corni (Fuck.) Trav., *D.*, scobina von Höhn., *G.*
Dilophospora graminis Desm. on *Holcus*, *A.*
Septoria Rubi West., *A.*
Monilia aurea Gmel., *D.*, *G.*
Ovularia obliqua (Cooke) Oud., *D.*
Botrytis cinerea Pers., *G.*, *A.*
Penicillium expansum Link, *A.*
Rhinotrichum Thwaitesii B. & Br., *D.*
Tilachlidium tomentosum (Schrad.) Lind., *D.*, *G.*

LICHENS OF THE MATLOCK FORAY.

By H. H. Knight, M.A.

The trees everywhere in this district were remarkably bare, the only corticolous lichens noticed being three common species of *Parmelia* and *Lecanora varia*. In Dovedale, with its exposed limestone rocks, lichens were plentiful, and here *Solorina saccata* in particular attracted notice. A species of *Arthopyrenia* growing on stones by the River Dove with *Verrucaria margacea* was named *A. arenicola* by Mr Paulson. All the lichens in this list were found on the Derbyshire side of the Dove. The rocks in the woods by the Via Gellia were too much sheltered by trees for lichens to be plentiful. The woods at Alderwasley were on Millstone Grit, and with the exception of the genus *Cladonia* were poor in lichens. Millers Dale was also visited; here the lichens were similar to those of Dovedale.

D. = Dovedale; *G.* = Via Gellia; *A.* = Alderwasley; *M.* = Millers Dale.

Chaenotheca melanophaea Zwackh, *G.*
Placynthium nigrum S.F.Gray, *D.*
Collema granuliferum Nyl., *D.*
C. furvum Ach., *D.*
Leptogium Schraderi Nyl., *D.*
L. lacerum Gray var. pulvinatum Koerb., *D.*
Peltigera canina Willd., *D.*
P. rufescens Hoffm., *A.*, var. praetextata Nyl., *A.*
P. polydactyla Hoffm., *D.*
Solorina saccata Ach., *D.*, *M.*
Parmelia physodes Ach., *D.*, *A.*
P. saxatilis Ach., *A.*
P. sulcata Tayl., *D.*
P. fuliginosa Nyl. var. laetevirens Nyl., *D.*
Cetraria glauca Ach., *A.*
C. aculeata Fr., *A.*
Xanthoria parietina Th.Fr., *D.*, *G.*, *A.*, *M.*
Placodium callopismum Mér., *D.*, *M.*
P. murorum DC., *D.*, *M.*
P. aurantiacum Anzi var. flavovirescens Hepp., *D.*
P. pyraceum Anzi, *D.*, *M.*
P. variabile Nyl., *D.*, *M.*
P. ochraceum Anzi, *M.*
P. rupestre Branth. & Rostr., *D.*, *G.*, *M.*
Candelariella vitellina Müll.-Arg., *A.*
Physcia caesia Nyl., *G.*, *A.*
Rinodina Bischoffii Koerb., *M.*
Lecanora muralis Schaer., *A.*
L. galactina Ach., *M.*
L. varia Ach., *D.*, *A.*
L. calcarea Sommerf., *D.*, *M.*
Lecania candicans A. Zahlbr., *D.*
Cladonia sylvatica Hoffm., *A.*
C. pyxidata Hoffm., *D.*, *A.*
C. fimbriata Fr., *A.*
C. rangiformis Hoffm., *D.*
C. squamosa Hoffm., *A.*
C. flabelliformis Wain., *A.*
Gyalecta cupularis Schaer., *G.*, *M.*
Lecidea lurida Ach., *D.*, *M.*
L. uliginosa Ach., *A.*
L. immersa Ach., *D.*, *M.*
L. ochracea Wedd., *D.*
Biatorina coeruleonigricans A.L.Sm., *D.*, *M.*
B. lenticularis Koerb., *D.*
Bilimbia aromatica Jatta, *D.*
B. sabuletorum Branth. & Rostr., *D.*
Opegrapha calcarea Turn., *D.*, *G.*
Dermatocarpon miniatum Th.Fr., *D.*
D. lachneum A.L.Sm., *M.*
Verrucaria margacea Wahlenb., *D.*
V. nigrescens Pers., *D.*, *M.*
V. glaucina Ach., *D.*
V. Dufourii DC., *D.*, *M.*
V. muralis Ach., *D.*
V. rupestris Schrad., *D.*, *M.*
V. integra Carroll, *D.*
V. calciseda DC., *D.*, *M.*
Thelidium immersum Mudd, *D.*
T. incavatum Mudd, *D.*
Polyblastia Schraderi A.L.Sm., *D.*
Acrocordia epipolaea A.L.Sm., *D.*, *M.*
Arthopyrenia arenicola A.L.Sm., *D.*
Porina chlorotica Wain., *D.*

RECENT WORKS ON LICHENS.

By A. Lorrain Smith, F.L.S.

THERE is no halting place in the study of Lichenology any more than in other branches of science, and though only a short time has elapsed since the previous record of work was compiled*, there has been a considerable accumulation of interesting material. Some papers that were then unavoidably omitted have been dealt with in the present survey and as in recent months the publication and exchange of papers has reached almost the freedom of pre-war years, it is hoped that on this occasion there are no serious lacunae.

The arrangement of subjects follows in the main on previous

* Trans. Brit. Mycol. Soc. VIII, pp. 193–200 (1923).

lines, but works on systematy have received more attention in view of the great importance of some of the publications, and because of the notes on general questions included with the descriptions of genera or species.

The Lichen Thallus.

Symbiosis or Parasitism. Tobler (1920, 1) has reviewed the theories of Schwendener and Elfving as to the relations between the symbionts in the lichen thallus and he also records his own observations. He found instances of perishing gonidia in the grip of the hyphae—instances in which the hyphae had the advantage and the gonidia tended to die off; but he also records cases where, owing to some conditions of habitat on growth, the gonidia increased enormously and the fungus succumbed. This would normally occur where there was excessive moisture or absence of light, etc. He concludes that in the lichen thallus there is constant balance of conditions between the two symbionts: the perfect balance he terms the optimum.

He discusses also the relation between alien fungi and the thallus of the lichens on which they frequently grow. He rejects the view that regards all these as purely parasitic fungi and prefers to look on them as "parasymbionts" living more or less in symbiotic union with the lichen gonidia.

Bachmann (1923, 3) has given a further contribution to this subject. He affirms the present almost universal acceptance of the theory of symbiosis, though some students still talk and write of *slavery, helotism,* or even *endosaprophytism* and *parasitism,* as expressions of the normal relation of the two symbionts. His recent observations prove still more decisively the healthy reaction on each other of fungus and alga in the lichen thallus. For instance, in the study of a fungus gall on the scyphus of *Cladonia fimbriata* he found striking evidence of mutualistic growth. The fungus had settled on the edge of the scyphus and formed there a large complicated outgrowth. Meanwhile certain soredia on the inside of the cup showed increased development, the gonidia had multiplied enormously, especially the round sporulating groups. This great development of gonidia could only be explained, he holds, by the amount of water and nutritious salts provided by the fungus hyphae. On the other hand the fungus profited equally by the increase of assimilative (gonidial) tissue. Bachmann recognizes a true symbiosis with exchange of inorganic for organic material. Sections through the gall showed a dense "mosaic" lichen tissue formed also of the stimulated hyphae and the algae.

He cites further instances of mutual stimulus in more normal growth: in *Anaptychia ciliaris* var. *verrucosa* the thallus, as the

name implies, has a warted aspect. Underneath the excrescences there was found a great increase of the normal gonidial band, as well as of loose hyphal filaments. He concluded that these warts served as aeration bodies; he found points on the basal layer where occurred openings to the thallus below. Bachmann also describes the effect of normal and abnormal pycnidial development—abnormally on the under side of a squamule, normally on the upper side, but in both instances accompanied by increase in the size of the squamule. As before he affirms the balance of development between the symbionts: as the pycnidial hyphae induce the increase of water and inorganic salts, the alga responds by the multiplication of green cells with their greater activity of photosynthesis.

In *Catillaria* (*Biatorina*) *synothea* he noted that when pycnidia were to be formed the thalline tissue always increased in thickness. The gonidia that perish in these processes serve undoubtedly as nutriment to the hyphae; but Bachmann holds that this is not parasitism; the death of these cells is comparable to the death of individual cells in the growth of a tree; it is a sacrifice to the greater good of the lichen as a whole. He sums up that though the lichen may not be regarded as one individual, yet it presents a physiological entity with astounding solidarity of the two component organisms.

Morphology.

Isidial formation. In certain lichens belonging to widely different groups—crustaceous, foliaceous or fruticose—isidia are normally developed on the surface or edges of the thallus; they are small thalline outgrowths, fairly constant and mostly of conical form, simple or branched, and are of service to the plant in increasing the assimilative surface as they always include the algal symbiont; since they are easily broken off, they aid in propagation. Linkola had already studied the formation of the somewhat abnormal isidia of *Peltigera lepidophora**. He has now contributed a paper (1922) on the densely massed marginal isidia of *Peltigera rufescens* var. *praetextata*. These isidia which occur as a thick fringe on the margin of the lobes may arise also on the edges of a wound in the thallus; they have even been observed on the back of the apothecia and—though somewhat rarely—on the under surface. That isidia should develop from the edge of a wound does not seem surprising—it may be regarded simply as an act of regeneration—but Linkola claims that the development in this case is unique and is only met with in this *Peltigera*. In *Umbilicaria* it is known that isidia are associated with wounds, but in that case the isidia were

* See Lichens, p. 161.

there first and have brought about the break in the thallus. Linkola thinks that the occurrence of the isidia should give this lichen specific rank as *Peltigera praetextata*.

Einar Du Rietz in his "Systematic Studies" (1922) has also given notes on the soredial and isidial species of *Peltigera*. Concerning *P. praetextata*, he states that in young plants the isidia may be wanting, but he finds, as did Linkola, that they develop quickly on any wounded portion. He inclines to associate this lichen with *P. canina*, though in Britain it has always been classified as a variety of *P. rufescens*. He also judges *P. lepidophra* to be closely allied to *P. canina*.

Pleurocarpy and Pycnothelizy. Examples of abnormal growth in *Cladonia* have been signalized by Bachmann in two papers. The first (1923, 1) deals with the excessive multiplication of pycnidia in some species. He found that they originated from the cortical layer, from the layer between the cortex and the gonidial zone or from the gonidial zone itself. Those that developed on the under side of a squamule took origin from the medulla. In all cases the abnormal increase of these bodies was accompanied by a great development of the gonidial vegetative tissue. Bachmann gives the term "Pleurocarpy" to this condition which was first observed in *Cladonia gracilis* var. *pleurocarpa*.

A second unusual development of fructification first noted in *Cladonia fimbriata* var. *pyknotheliza* has been designated "Pyknothelizie" by the same author (1923, 2). The fructifications—pycnidia and apothecia—appear both on squamules and on podetia and are extremely abundant. The abnormal growth is, here also, accompanied by a corresponding increase of the vegetative tissue—the enlarged gonidial zone, larger squamules, and numerous soredia and isidia. Bachmann (1919) had recorded a similar excessive gonidial and vegetative development in *Parmelia physodes* in an unusual outgrowth with pycnidial development. The gonidia in that case also had increased enormously and were most of them surrounded by delicate hyphae.

Further work has also been done by Bachmann (1924) on unusual developments in *Cladonia podetia*. He has found that adventitious shoots are very common in ascyphous *Cladoniae* and that they arise from the gonidial meristem. In one case he found a new shoot associated with a gall in a podetium of *Cladonia cornuta*, in which instance the new shoot burst inwards and developed in the hollow of the podetium. It originated about 5 mm. from the tip and the intervening space was infected by the hyphae of the gall fungus. The shoot

was of reduced stature, probably owing to want of organic nutrition; it had no gonidia of its own and was entirely dependent on the nourishment provided by the gonidia of the host podetium. He states that had it reached the open it would doubtless have soon acquired gonidia from external sources which brings him to the affirmation that the podetial gonidia, as Krabbe believed, arrive from the open.

Another peculiarity of the adventitious shoot was the reduced amount of medullary tissue; its development for strengthening purposes being unnecessary. He noted also the unusual thickness of the hyphal cell-walls, the small amount of plasma in the outer hyphae of the medulla and along with these developments the change of the apical meristem to resting tissue. He explains all these phenomena by the lack of sufficient nutrition, that is, by the absence of gonidia with their contribution of organic material.

Bachmann previously was of opinion that the inner podetial medulla could not change to meristem; he now finds that even this unpromising tissue under the irritation of the fungus gall can become meristematic and aid in the formation of new shoots.

The excessive development of gonidial tissue in response to new demands had already been described by Bachmann (1919) in a study of fungal parasites on *Parmelia physodes*. Galls, with their increase of tissue, were formed where the fungus had attacked the thallus. He points out the relation between the fungal hyphae and the greatly increased gonidia of the lichen; at first, as in cases of "parasymbiosis," the fungal hyphae shared along with the lichen hyphae the nutrition supplied by the gonidia; but at a later stage the lichen hyphae were pushed aside by those of the parasite which then closed narrowly round the gonidia. The lichen hyphae were later attacked and absorbed by the fungus which, though parasitic in regard to these lichen hyphae, continued to live symbiotically with the algae.

Physiology.

Disintegration of glass and rocks by Lichen thalli. In a recent paper Ethel Mellor (1923) reviews the work already done by her* at the Sorbonne, Paris, on the damage caused by lichen growth to church windows. In summing up she attributes the corrosion to (1) the effects produced by the lichen acids, and (2) to the effect of carbonic acid dissolved in water. From one or both of these causes the glass is gradually weakened and perforation may occur. The first stages, she holds, are due to the colonization on the glass of minute, poorly-developed

* See Trans. Brit Mycol. Soc. VIII, p. 199 (1923).

crustaceous lichens. A small series of larger lichens—*Ramalina polymorpha* var. *ligulata*, *Xanthoria parietina* and its var. *tumida*—arrive at a later stage and aid the process of disintegration.

A somewhat different view of glass corrosion by lichens is suggested by E. J. Fry (1924). Her study of rock lichens had convinced her that the gelatinous substance of lichen hyphae, more especially of the attaching rhizoids, probably acted mechanically on rocks and on glass in the same way as a gelatine film. She cites the known fact that when a solution of gelatine is spread over a glass plate and dried quickly, the gelatine contracts and curls up at the edges in the process of drying; and its hold is so fast that comparatively large shell-shaped portions of the glass are torn from the surface. She carried out a series of experiments with gelatine on glass and on shale, and in both instances a film of the substratum adhered to the drying and contracting gelatine. Attention was then directed to the action of lichens on smooth unweathered and unaltered shale. A portion with a lichen attached was moistened and dried again, one or more times; examination showed that thin films of the rock adhered to the lichen. E. J. Fry therefore considers that the first process of disintegration is due to this mechanical action, and only later are the separated fragments decomposed by acids.

Water storage. Bachmann had studied the water-content of immersed limestone lichens. He has now (1923, 4) published the results of a study as regards water-storage of those that live on hard siliceous rocks. He finds that the foliose lichens, *Umbilicaria pustulata* and *Gyrophora* spp., have a capacity of water absorption and retention much greater than that of crustaceous lichens. In the case of *Umbilicaria* it is due to the pustulate character of the thallus; in *Gyrophorae* the water is stored and held in the dense medullary tissue. In crustaceous silicicolous lichens water is absorbed in various ways; in some it is in the "hyponecral" zone, that is the zone beneath the gonidial layer which contains many sheaths of empty gonidia, these sheaths serving as reservoirs for water. Water escapes from such lichens more rapidly than from limestone species which are more or less embedded in the rock. Easily-broken rocks—roughened on the surface—seem to encourage the growth of a thick type of thallus with its enlarged capacity of absorbing water, and the thick cortical layer of disorganized cells present in many of these forms certainly delays evaporation. In lichens such as *Placynthium nigrum*, the largely developed hypothallic structures retain water. Some lichens, such as *Rhizocarpon*

geographicum, spread widely over the hard stone in a thin layer and without any special storage structures, but such lichens have a special capacity of retaining life during long periods of drought, as do the desert lichens. In the preface to Bouly de Lesdain's supplement to *Lichens du Mexique* (1922) it is stated that on the high Mexican plateaux there are two seasons; from the end of May to October, when rain falls in torrents every day, and the alternative six months which are dry. All through the dry months lichens support direct insolation and an extremely dry atmosphere; they are both varied and abundant, but if collected during that period they fall to powder in the hand.

It is well known that blue-green lichens and algae also manage to exist in extreme desert conditions. H. H. Thomas, in his study of Libyan plants (1921), records an instance of this: he found a lichen, the algal constituent of which was a *Gloeocapsa*, growing closely attached to a pebble in full insolation and in company with colonies of the alga. The lichen was brought home and was still living under laboratory conditions after a period of five years.

Cells and cell-contents. Salkowski (1920) has made a study of carbohydrates and the fermentative products of the lichen cell; he tested the hemi-celluloses of *Lichen islandicus* and *Cladonia rangiferina* by hydrolysing air-dried material with sulphuric acid (H_2SO_4). As a result he obtained 60 per cent. fermenting sugars. Sodium chloride, in strong concentration, restrained fermentation and more effectively with high percentages of sugar. With only 12 per cent. of sugar and 4 per cent. of sodium chloride fermentation was complete. Diastatic ferments did not destroy sugar in lichenin. Some substance that hindered fermentation was detected, probably a lichen acid. The content of cetraric acid was reckoned to be at least 10·92 per cent. of the air-dried substance.

A criticism of Mameli's views on lichen starch has been contributed by Cengia-Sambo (1923). He did not find starch in the gonidia; in these bodies the first product of assimilation was oil, but he does not attempt to explain the process of primary oil-formation.

In the membranes of the gonidia he found the carbohydrate present to be amilodestrin. With free *Protococcus* algal cells he got the same reaction for amilodestrin, viz. rose-violet on the application of iodine, but in these he demonstrated the presence of starch.

In his study of the asci he made use chiefly of *Anaptychia ciliaris*; in the early stages he distinguished three layers in the ascus membrane: an outer membrane of amyloid structure,

within that a layer of glycogen, and a third more granulose protoplasmic layer which provides for spore formation. As development proceeds the glycogen becomes transformed to oil which serves as nutrition for the spores. The oil reserve within the spore serves to nourish the germinating hypha.

As regards photosynthesis, Henrici (1921) states that in lichens as in other plants there are light and shade forms, and that if extreme shade lichens are exposed to strong light, assimilation ceases altogether. He found that the light optimum for lichens was lower in the shade forms.

Lichen acids. New facts regarding the chemistry of lichen acids are recorded by Hepworth (1924) in his book on organic products (chap. IV). Compounds with tannin-like properties had been investigated by Fischer and had been termed by him "Depsides" from the Greek, to tan. Lichens are the only natural source of the depsides so far discovered. Three acids associated with depsides are orsellnic, lecanoric and everninic, and all three have been synthesized by Fischer or by Hoesch. Vulpinic acid, which occurs in *Letharia vulpina*, was synthesized in the laboratory by Volkard* in 1894, the only instance of the synthetic preparation of a lichen acid previously recorded.

Use of reagents. There is not much to record under this heading. Anders (1923) gives a note with regard to the necessity of care in applying the reagents in *Cetraria hepatizon*; on the application of potash the medulla of the thallus gives a yellow colour which becomes red only after some hours. Magnusson (1924) recommends the use of potash in studying the formation of the apothecium and the septation of the paraphyses. The sections after such treatment may be washed and then neutralized with sulphuric acid (dilute); the addition of iodine will make clear the lumina of the cells, the texture of the hyphae, etc. In testing with potash (K) he is accustomed to place a thick section on a slide in a drop of the solution. "If there is a positive reaction of yellow then red is expected, a yellow mist will be formed first in which thin rusty needles appear." In examining with CaCl he scrapes off a bit of the thallus with the wetted point of a knife, mounts it in a drop of water and adds a grain of calcium hypochlorite (bleaching powder). In a few seconds the colour will appear. Magnusson has found—as others have done—that the reaction with potash cannot always be relied on.

Bionomics.

Rate of growth in Lichens. Several papers within recent years have dealt with the somewhat debated subject of the rate

* Lichens, p. 228.

of growth in lichens. Linkola (1918) has recently carried out measurements on the rate of growth of *Parmelia* spp. in Finland which confirm the observations of previous workers. The measurements were made at intervals of one year between the autumns of 1910–11 and 1911–12, and then at a longer interval, 1912–16. He gives the average of the three tests for each species. The results of growth for a year were: (1) *Parmelia sulcata*, 1–6 mm.; (2) *P. centrifuga*, 2·5 mm.; (3) *P. olivacea*, 0·7 mm.; (4) *P. physodes*, 1·6 mm.; (5) *P. ambigua*, 0·7 mm. and (6) *P. aleurites*, 0·7 mm. These lichens grew on palings, except *P. centrifuga*, which was found on granitic rocks. Comparing the size attained by the lichens with the rate of growth, he concluded that No. 1 would be 30–40 years of age; No. 2, 50–80 years; No. 3, 50–60 years; No. 4, 30–40 years; No. 5 (*P. ambigua*, on which shade conditions had reacted unfavourably), 15–20 years; and No. 6, 20–25 years. Linkola thinks that the limit of age in Finland had been reached by these species.

There are also records on the origin and growth of lichens by Tobler (1920, 2). He studied more particularly the development of *Cetraria* on *Fagus* and *Picea*. The chief means of propagation was by soredia and he considered that a composite plant might, and did, arise by the mingling of several soredial individuals. The calculation of yearly growth is thus a little complicated and must be taken from the point of origin and not the whole width of the thallus. The lichen developed more easily on *Fagus* than on young growths of *Picea* owing to the different characters of the bark; the rate of growth was however practically the same—about 1 cm. increase of the young thalli in the year. This is a much higher estimate than that of Linkola; but the latter was dealing with long-established plants of mature growth.

Substratum. An interesting study on the relation between lichens and their substratum in the case of those that grow on bones has been contributed by Bachmann (1920). He studied the exact manner of growth of a number of crustaceous species, all of which were erratic on bones. He divides them into two classes, "exostitisch" and "hypostitisch," according to their lodgment without or within the substratum. He found that in no case did they draw any nutrition from the osseous tissues, but that the bone, owing to its porosity, not only gives shelter to the thallus (when it is "hypostitisch"), but also receives and retains water which is a distinct advantage to the lichen. The lichen hyphae he decided had no power of boring channels, as in limestone; the growth is purely superficial. He speculates on the question as to whether endolithic lichens, such as some

Verrucariae, might not retain their boring power if transferred to bone. Bachmann cites the case of fungus hyphae having been found in fossil bone; but the living example of *Onygena equina*, which grows only on bones, might prove still more instructive, as of necessity the fungus there is dependent on the bone for nourishment.

Magnusson (1924) found that *Acarosporae* are extremely selective as to their substratum; most of them grow on granitic or siliceous rocks, a few are as exclusively calcicolous. Those that avoid limestone are to a large degree nitrophilous lichens: *A. fuscata*, *A. nitrophila* and *A. peliocypha* inhabit by preference the summits of rocks where birds congregate, or the lower slopes washed by water charged with the excreta. He noted that *A. fuscata* collected from a situation deprived of nitrogen supply had a thinner, lighter-coloured thallus and was mostly sterile. Other *Acarosporae* grow where there is a plentiful supply of dust laden with nitrogenous particles, such as road sides or the proximity of barns. Several species of aquatic or semi-aquatic habit are also presumably nitrophilous. One species, *A. insolata*, he records as seemingly non-nitrophilous, but it lives intermixed with other crustaceous lichens and may obtain nitrogen from its associates; he compares it with *Lecanora atriseda*, which destroys *Rhizocarpon geographicum* and then lives saprophytically on the dead thallus.

Ecology, Distribution and Systematy.

These three aspects of plant study are so closely connected that it seems best to consider them together. It has not previously been thought advisable to include purely systematic works, but many of those recently published contain valuable notes on distribution as well as on ecology.

Polar Lichens. From the far south there are two records by Darbishire, both published in 1923, (1) of lichens, collected in 1910 by the Terra Nova, and (2) Cryptogams brought home by Sir Ernest Shackelton's Expedition. The latter collection includes some 15 species, one being new to science; they were found on the slopes of Mt Erebus or on Elephant Island. In the former more important paper Darbishire reviews the present position of our knowledge of Antarctic species, more especially as compared with Arctic. Hue in his work on the French Antarctic collections (1903–5 and 1908–10) had found and described so many new plants that he came to the conclusion that the lichen flora of Antarctica was largely unrelated to that of any other region*. Darbishire concedes that Hue's experience

* See Lichens, p. 347.

somewhat alters his previous percentages of common forms, but again points out the remarkable similarity between the lichens of the polar areas. He tabulates these in their relation to the two poles as follows:

Fruticose lichens: 12 in common or 44 per cent. of the whole number.

Foliaceous lichens: 9 in common or 32 per cent.

Crustaceous lichens: 28 in common or 18 per cent.

The highest percentage is thus to be found in fruticose or shrubby lichens, and seems, Darbishire considers, to indicate the greater antiquity of these highly developed forms. In the Terra Nova material were 17 lichens, 9 of which were new species, 7 of them belonging to the genus *Buellia*. Most of these polar lichens are characterized by a very dark thallus and predominating black hypothallus, though brighter tints, especially yellow, are not wanting.

Spitzbergen, which lies well within the arctic circle, was visited in 1921 by members of Oxford University, and the lichens which were collected by V. S. Summerhayes were examined and determined by R. Paulson (1923). The specimens represented 27 genera and 68 species, most of them ground or rock dwellers, and most of them healthy and abundantly fertile, with the gonidia sporulating freely. *Cladoniae* ranked high in point of numbers both of species and individuals—*C. pyxidata* perhaps the commonest of all, though often starved and deformed. Paulson particularly notes the ubiquitous nature of *Lecanora tartarea*, which takes fantastic forms as it spreads over other vegetation.

Lichens of temperate zones. Bouly de Lesdain (1924) has described the flora of a district on the dunes of Belgium, chiefly an alder thicket and the "möeres," which are dried up lakes. The whole district is drying owing to drainage, with the consequent disappearance of trees and of atmospheric moisture. Most of the lichens were epiphytic on the trees of the thicket. In his general remarks he notes that *Parmelia* and *Ramalina*, that grow on isolated trees in colonies, were, in the wooded area, of much sparser growth. *Parmelia physodes*, common enough on old wood in the immediate neighbourhood, failed altogether on the isolated trees and was rare in the thickets. Lesdain chronicles 90 lichens for the district, several of them new species or varieties.

A paper published by F. Erichsen some years ago (1916) gave an interesting account of the lichen vegetation on the sand-dunes of the German coast. Near Neustadt, in Holstein, there occurs a stretch of dunes known as the Pelzerhaken; they do

not reach any considerable height and are thickly interspersed with boulders and flints of varying size. Erichsen recognized there five distinct zones of vegetation; in the first zone nearest the sea, and often covered with the tide, he found only one small thallus of *Verrucaria halophila*. The two succeeding zones were occupied mostly by halophytes; the stones—chiefly flints—were subject to rolling caused by the higher tides and only small beginnings of lichen thalli had found a footing on them. The fourth zone, with its more firmly embedded stones and stable soil, gave a rich harvest of dark-coloured crustaceous forms—among the more abundant *Buellia aethalea* and species of *Rhizocarpon*, with various soil species, such as *Cladoniae*. It was noticeable that even grey forms like *Cladonia sylvatica* shared in the brown coloration and had developed brown tips on the branches. Between cushions of moss there spread the dark thalli and apothecia of *Lecidea uliginosa* and *Bacidia muscorum*. Lichens of a gayer colour were not entirely absent; yellow *Xanthoriae*, dove-gray *Physciae*, *Parmeliae* and *Lecanorae* being fairly abundant. A marked feature in all these lichens was the dwarfed character both of thalli and fructification. Erichsen listed 59 species from the area.

A very different type of locality is dealt with by C. P. Hurst (1923) in his *East Wiltshire Lichens*. His chief hunting ground was Savernake Forest and the surrounding country. The absence of rocks explains the fact that only one *Lecidea* is listed—the very common corticolous *L. parasema*. Corticolous species of other genera, as was to be expected, are well represented, not only the crustaceous, but also the more highly developed foliose or fruticose forms.

Jos. Anders (1923) has described the lichens in the Isergebirge. The highest point of the range, the Tafelfichte (1122 m.), is entirely covered with pine woods and on stems, branches and stumps he found in great abundance the rather rare lichens *Parmeliopsis aleurites*, *P. ambigua* and *P. hyperopta*; among crustaceous species *Lecanora symmicta*, *L. argentea*, etc., and *Mycoblastus sanguinarius* were abundant, the latter very noticeable where the thallus had been frayed, thus revealing the blood-red tissue below the apothecia.

The Carpathians have been examined from an ecological point of view by Jindrich Suza (1922) in his *Lichens of the Těšínsko Tchécoslovaque in Eastern Silesia*. The mountains attain a height of 1000 m. on the southern side, declining towards the north to a high plateau. There is much humidity in the forests at the summits of the mountains and the epiphytic lichen flora is very rich, but only in individuals; there is no great variety of species. Comparison is made between the lichens on

Picea excelsa and on *Fagus sylvatica*. On the former are to be found several species of *Cladonia, Sphaerophorus coralloides, Parmeliae,* etc., with *Mycoblastus sanguinarius,* but none of the *Trentepohlia* lichens—Graphidaceae, etc. On the beech with a smoother bark, no *Cladoniae* were found, but various *Parmeliae,* a few *Graphideae* and other crustaceous species. Several were common to both types of tree trunk.

Charles Plitt has studied the lichen vegetation in four ecological stations at Mount Desert Island, Maine, U.S.A.; these are designated: (1) the White Pine station; (2) the Pitch Pine station; (3) the Spruce station; and (4) the Oak station.

The White Pine (1), at an altitude of 200 ft., consisted almost solely of *Pinus Strobus. Cetraria lacunosa* and *Parmelia physodes* were almost equally abundant on the trees; next in quantity, *Nephromopsis ciliaris.* A list of 41 lichens was made at this station in the order of their frequency.

Pitch Pine station (2) is situated at an altitude of 650 ft. and a great change was noted; only a bit of *Cetraria lacunosa* was found and a bit of *Nephromopsis.* Here *Parmeliopsis aleurites* and *Mycoblastus sanguinarius* vied with each other for supremacy. A list of 37 species was made.

Spruce station (3) (80 ft.) showed a still greater change; the branches of the trees were festooned with *Usnea* and the trunks decorated with *Lobaria pulmonaria* and *Pertusaria amara,* while *Peltigera polydactyla* formed large rosettes on the moss-covered ground. Some 29 species were listed here.

The fourth or Oak station was poor in lichens, only 21 species being collected; the most common of all was *Conotrema urceolatum*; every oak that had retained smooth bark had "a liberal growth of this lichen."

Plitt visited later another White Pine forest in order to compare the lichen growth with that of the "White Pine" station. There was a considerable admixture of Spruce, but here again *Cetraria lacunosa* was most conspicuous. There was scarcely a tree of *Pinus Strobus* on which the lichen was not present, though it was scarcely ever seen on the Spruce. It was quite possible in this forest to distinguish between these trees by the lichen growth.

Still another study of lichen growth has been undertaken by C. Plitt and Louis J. Pessin (1924). They have sought to determine the correlation between the evaporating power of the air, the intensity of the light, and the distribution of the lichens along the height of a tree and around its circumference. The experiment was made on a tree (*Quercus rubra*) a little over 13 m. in height and about $\frac{1}{2}$ m. in diameter at 2 m. from the ground. It grew on Mount Desert Island, Maine, in rather dense woods and was fairly well covered with lichens: 28 different species

were determined. The tree was divided into zones; the lichens in each zone were enumerated; light and moisture were tested at regular intervals.

The writers found that the evaporating power of the air was the chief factor in the distribution of the lichens; it was found to be of much more importance than the intensity of light. Certain plants, such as *Leptogium tremelloides*, *Pertusaria amara* and *Lobaria pulmonaria*, only occurred in areas of low evaporation; species of *Usnea* and *Ramalina* only where evaporation was high and light intense. *Xanthoria parietina* was found in only one patch near the top of the tree on the north-west side, though *Xanthoria* is essentially a sun-lichen.

Tropical Lichens. In an account by Malme (1922–3) of lichens collected in the first Regnell Expedition to South America, special emphasis is given to the influence of moisture as well as of temperature on the growth of these plants. He found, for instance, that the flora in the coastal regions—Rio de Janeiro, Santa Catharina, etc.—differed widely from that of Matto Grosso, an inland locality. He cites as evidence the presence of only a few species of Stictaceae in the central region, while at the coast they were in great numbers both of individuals and species. It was the same with the genera *Ramalina* and *Teloschistes*; of the latter he says, indeed, no species was collected in Matto Grosso. Crustaceous species also differed widely in the two regions.

Another paper touching on the lichens of tropical lands is that of William Seifriz on the ecological survey of Mt Gedeh, Java (1923). He divides the mountain into four botanical zones: the first of these at an altitude of 4600–5500 ft. is characterized by its big trees and somewhat open ground. The great trunks in that region were sometimes completely covered with lichens, giving to the bark the appearance of an elaborate mosaic; *Graphideae* and *Pertusariae* were well represented. The foliose genus *Sticta* was also in abundance. The next highest zone (5500–7000 ft.) was a forest and fern area; the trees were profusely draped with mosses, and the lichens were either crowded out, or their development was inhibited by the absence of light, lichens being peculiarly sun-plants. From 7000 to 8000 ft., designated as a herbaceous zone—an open and sunny region—mosses were absent and lichens were again numerous, *Usneae* being specially luxuriant. The *Vaccinium* zone, nearest the summit (8000–9000 ft.), was also characterized by many lichens, most of which had not appeared in the lower zones. A species of *Cetraria* was "the most common at this altitude, growing in large fluffy cream-coloured patches."

Also from Java comes a first paper on the ecology of epiphytes by Paul van Oye (1924). The paper so far deals only with four host trees: *Bambusa*, *Oreodoxa regia* (Palm), *Areca Catechu* and *Cocos nucifera*. Among bamboos those trees that grow in the open are most covered with epiphytes, chiefly lichens.

On *Oreodoxa* the epiphytes were again mostly lichens with a few other growths of mosses and orchids. The lichens were larger and more developed than those on *Bambusa*. The stem of *Oreodoxa*, rather slender at the apex, suddenly widens out some way below; on this larger surface the lichens are seated, their growth being favoured by the water which after trickling down the narrow part spreads over the enlarged area.

Areca Catechu. Any lichens found were mainly on old and dry stems; the epiphytes on normal trees were chiefly mosses and *Trentepohlia*.

Cocos nucifera. On this tree there were even fewer lichens, but *Trentepohlia* was abundant.

Geographical distribution. Suza (1922) records an arctic lichen, *Nephroma expallidum*, in the High Tatra (Czecho-Slovakia) and compares it with the presence of other arctic lichens, such as *Parmelia centrifuga* and *Cetraria odontella* in Central Europe, though not in the Alps. He concludes that these lichens are relics of the glacial period. A more astonishing record is that of *Usnea sulphurea* (*Neuropogon melaxanthus*) on the coast of Norfolk, recorded by Maheu and Gillet (1923). In that case the lichen probably had been brought by a ship from some far distant polar area; it can hardly be regarded as a British species. In contrast with the high altitudes we have the work of Jozef Motyka, also in the Carpathians, but in the valley Kosueliska, on the western side of the Polish Tatra. His attention was given to forest species, to those of alpine prairies, and to the forms growing on siliceous rocks. The district must be typical of temperate Europe, as there is an astonishing similarity between the lichens of the Tatra and those of the British islands, though on the whole they correspond rather with those of our hilly districts. Graphidaceae are very poorly represented, while *Cetraria*, a truly northern genus, furnished 13 species.

An important paper has been contributed by A. Zahlbruckner (1924) on the lichen flora of Juan Fernandez. The "Robinson-Inseln" has had a romantic interest since Defoe's day, and recently the natural history has been thoroughly explored by a Swedish expedition under the direction of Carl Skottsberg, who, with the help of his wife, made large collections of lichens along with other plants. Zahlbruckner has collated with these the records of previous workers:—Bertero's collection examined by

Montagne; W. J. Hooker's lichens described by T. Taylor; the material of the Challenger expedition, of which Crombie had charge, etc. The list for the island now stands at 185 species, and these, divided according to the algal symbiont, are: combined with bright green (Protococcaceae), 109 species, or 60 per cent. of the whole; with blue-green algae, 48 species, 25 per cent.; with *Trentepohlia*, 28 species, or about 15 per cent. Zahlbruckner finds the lichen flora to be partly Chilian in origin and partly subantarctic American. He describes a considerable number of new species—so far endemic, but possibly to be found elsewhere. As compared with the lichens of Samoa, which also were worked out by him, he notes a considerable falling off in lichens that are combined with *Trentepohlia*, these being generally abundant in the tropics; the high percentage of blue-green lichens remains about the same, that type of lichen being peculiarly a denizen of volcanic islands.

More definitely tropical are the lichens of the Philippine Islands, a large instalment of which have been published by Wainio (now Vainio) (1921). A very large number of new species have been determined as well as new genera. It is interesting to find here also the large percentage of Phycolichens (blue-green) and to note the predominance of tropical genera, such as *Thelotrema*, *Sporopodium*, *Graphis*, etc.

An exhaustive work on Finnish lichens is in course of preparation by Vainio. Two sections have already appeared, the first, which comprises the Pyrenomycetes (1921), is extremely welcome, as Th. Fries in his fine work on Scandinavian lichens did not include that group. In the second (1922) he takes up Baeomyceae and Lecideales. Under the former there is only one genus, *Baeomyces*; the sub-tribes Cladoniae and Lecideales follow. He enumerates 45 species of *Cladonia*, a genus very abundant in northern regions. The Lecideales are unfinished. Vainio has substituted for *Lopadium* an older name, *Sporopodium* Mont. The remaining parts of this great work will be eagerly anticipated.

A. Magnusson (1924) has just completed and published his monograph of Scandinavian *Acarosporae*. The genus is characterized by the many-spored asci, the spores being mostly very small bodies. In our own islands we have a record of 12 species; Magnusson describes 35 for his territory, but 9 of these are new to science and his own discovery. *Acarosporae* almost exclusively inhabit rocks and are to be found, rather monotonously so far as Great Britain is concerned, in "maritime or upland" regions. There is one fairly common and brightly-coloured species, *A. chlorophana*, which has not been reported in the British Isles, though it extends well over the continent. Mag-

nusson says: "As far as I know *A. chlorophana* always grows under overhanging rocks, where it may cover large areas more or less densely with its conspicuous yellow thallus, and therefore it has been noticed from numerous localities."

The contribution by Savicz (1924) on the *Cladoniae* of Kamtschatka contains much that is valuable on the distribution of the genus. Thirty-seven species have been determined with numerous varieties, some of them new to that region or new to science. They belong chiefly to the "circumpolar" group and are an important part of the vegetation, especially on the "tundras" of the sea-coast, where species of *Cetraria, Thamnolia, Sphaerophorus, Bryopogon* and *Nephroma arcticum* cover enormous areas.

Of the three "reindeer mosses," *Cladonia rangiferina, Cl. sylvatica* and *Cl. alpestris*, it is the last mentioned that is the most abundant on the mountain "tundras." Savicz is inclined to the belief that it is also the species that is most sought after by the reindeer. Bernt Lynge has told us of its extensive use as fodder in Norway. Savicz also notes the peculiarly white colour of this lichen in Kamtschatka.

Systematic notes. Einar Du Rietz in his *Lichen Systematic Studies* (I, 1922), after careful work, has given specific status to a lichen not uncommon in our own upland rock districts, but listed hitherto as *Cladonia lepidota* form *hypophylla*. It was described by Crombie (Monogr. I, p. 16 *a*) as most probably referable to *Cl. cervicornis*, and by myself (Monogr. I, ed. 2, p. 438) as "a very peculiar form, the podetia having the appearance of enlarged squamules" and "apparently very near to some growth form of *Cl. cervicornis*." Its frequent and abundant growth in Scandinavia, always in characteristic form, induced Du Rietz finally to place it in a separate species as *Cl. subcervicornis* DR.

A new species is also described in Study II (1922), *Leptogium Sernanderi*, a rare form belonging to the bluish- or leaden-coloured section of the genus. His views on *Leptogium* spp. do not always coincide with those of British lichenologists: we consider *Lichen cochleatus* Dicks. as undoubtedly synonymous with *Leptogium tremelloides*, renamed *L. cyanescens* by Du Rietz, who refers it to *Collema rivulare*. In his third contribution (III, 1924) he finds two species described under *Cetraria lacunosa*; the one familiar to us in Britain, bearing isidia, he classifies as *C. norvegica*, the true *C. lacunosa* being, he finds, an American plant without isidia.

A monograph of all known *Crocyniae*, prepared by Abbé Hue before his death, has been edited and issued by Bouly de

Lesdain (1924). It concerns an obscure genus of lichens of which only one, a tropical species, *Crocynia gossypina*, has hitherto been known as fertile. A new species with fructification, *C. antecellens*, has recently been found in southern France. A very large series of species formerly considered as imperfectly developed thalli and sometimes placed in the old genera, *Lepra* or *Lepraria*, are now definitely diagnosed and described as species of *Crocynia*. Quite a number of these are British. In the introduction to the paper Lesdain justifies the present publication, though indicating that further work may probably lead to more close grouping. The giving of definite specific rank to so many sterile thalli, several often from one locality, tends to fill the systematist with dismay, but more experience may reconcile one to the French point of view.

Charles Plitt has published a diagnosis and description of a new species of *Crocynia* from California. A number of *Crocyniae* have been described on thalline characters, as stated above, most species being sterile. Plitt has drawn out a table of all those species with Protococcaceous gonidia, none of which agree with his specimen. An interesting peculiarity is that the thallus is dotted with minute red specks which proved to be scale-insects. Plitt notes that *Crocynia maritima* B. de Lesd. is characterized by red specks and suggests that these also may be due to the presence of insects.

Among authors with different views there is a constant shifting in classification of doubtful species from lichens to fungi and from fungi to lichens. Of late years the tendency has been to classify all these doubtful forms as fungi. Bachmann (1923, 5) has reversed the process in the case of *Bactrospora dryina*, first described as a lichen, but which, for some time, has been placed among the Discomycetes as a member of the Patellariaceae. The structure has been examined by microtome sections, and the bark on which it grows has been found to contain a very healthy and well-developed thallus, mostly however within the bark. He claims that *Bactrospora* is an undoubted lichen.

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STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate X and 1 Text-fig.)

VI. CEPHALOSPORIUM AND ASSOCIATED FUNGI.

By T. Petch, B.A., B.Sc.

A. *Cephalosporium* (*Acrostalagmus*) *Lecanii* Zimm.

THIS fungus appears to have been first observed in Ceylon about 1861. Nietner, in his pamphlet on *The Coffee Tree and its Enemies*, published in that year, stated: "It has been mentioned to me that the bug was subject to a disease—a white covering forming over it and destroying it. This is simply mould." The "bug" was *Lecanium coffeae*.

The fungus was subsequently found by Zimmermann on *Lecanium viride* on coffee in Java, and was briefly described by him under the name *Cephalosporium Lecanii* in a short paper in 1898. He stated that each dead scale was surrounded by a white fungus which consisted of fine hyphae radiating from the scale over the surface of the leaf for a distance of about 1 mm. The hyphae gave rise to short lateral branches, each bearing at the apex a large number of conidia, which were united by slime into a sphere. If, however, the sphere was placed in water, the slime dissolved and the conidia separated. The conidia measured $3{\cdot}5 \times 1{\cdot}5\mu$.

Zimmermann cultivated the fungus on nutrient agar, but as the object of his paper was to direct attention to the possibility of utilising the fungus to control the scale insect he did not give further details.

In a later publication (1901), Zimmermann stated that he obtained very strong cultures on a medium consisting of 2 per cent. agar, 1 per cent. peptone, 4 per cent. cane sugar, and 0·5 per cent. Liebig's meat extract. The fungus grew very slowly, being first visible to the naked eye after about five days, spores being produced on about the eighth day. The mycelium was at first white, and subsequently became yellowish.

Zimmermann recorded that he had received specimens from Mr E. E. Green in Ceylon which were identical with the Javan species.

Parkin, in 1906, recorded *Cephalosporium Lecanii* from Ceylon on *Lecanium viride, L. hemisphaericum* and *L. nigrum*. His account is as follows:

"The fungus shows itself to the naked eye as a white or pale yellow powdery bloom around, and to some extent over, the scales. The powdery or mealy appearance is due to innumerable conidial heads covering the hyphae. The external part of the fungus develops as follows: Hyphae radiate out on all sides from below the scale for a millimetre or more over the leaf surface. Each hypha produces at frequent intervals short lateral branches, the conidiophores, 16–20μ in length. Each conidiophore bears on its apex a spherical head of conidia enveloped in mucilage. This head, with a diameter of 4μ, appears when dry as a glistening globule, the individual conidia not being distinguishable. On treatment with water the mucilaginous matter dissolves and the conidia are dispersed; sometimes the last produced remains attached to the tip of the hypha. In order to examine the conidia *in situ*, the fungus should be mounted in dilute acetic acid, which prevents the mucilage from dissolving and renders the conidia visible. Five to seven are usually present in one head. They are really abstricted from the conidiophore in succession, but instead of remaining in a chain become aggregated together into a spherical mass by the mucilage which is secreted. Some infected scales kept in a damp atmosphere showed conidiophores bearing conidia in short chains, owing perhaps to mucilage not being able to mass them together*. The colourless conidia are minute, measuring 3·5–4 × 1·4μ, figures almost identical with those given by Zimmermann for the Java form. They are shortly cylindrical or nearly oval or slightly sausage-shaped.

"The conidiophores may be so numerous that here and there the mucilaginous heads, which touch one another, fuse to form larger masses of conidia.

"The lateral branches of the main hyphae which here are

* This is another species.

termed conidiophores may even branch themselves, so as to produce two to four heads of conidia.

"If a scale from affected material, but with no external fungus visible, be removed from a leaf and placed on a microscopic slide in a damp chamber, the development of the conidial part outside the insect can be readily followed. After one day the radiating hyphae proceeding from the margin of the scale were just visible: after two days the first conidiophores appeared, and after four or five days the whole insect was surrounded by a fringe of hyphae bearing numerous conidial heads.

"An example of *Cephalosporium* parasitic on *Lecanium hemisphaericum* var. *coffeae* on the stem of *Jussiaea suffruticosa* possessed a few perithecia. These were resting on the peripheral part of the fungus, and were globular in shape and pale yellow in colour. The long asci within unfortunately showed no definite spore formation and so were most likely immature. However, their presence points to the probability of this *Cephalosporium* being a conidial stage of some genus of the *Hypocreales*, to which group nearly all the other Ascomycetous scale-fungi described belong."

This species is very common in Ceylon on *Lecanium viride*, especially on coffee. It has also been found in Ceylon on *Lecanium nigrum*, *L. hemisphaericum*, *L. coffeae*, *L. expansum*, *Ceroplastes* sp., and a black *Aleyrodes*. Specimens from south India on *Lecanium viride* on coffee are identical with the Ceylon form. Mr W. W. Froggatt has kindly forwarded me specimens from New South Wales, on *Lecanium oleae* on *Phormium tenax*, and I am indebted to Mr G. H. Cunningham for specimens on a scale insect on *Citrus* from New Zealand.

On *Lecanium viride* the hyphae of the fungus grow out from beneath the scale over the surface of the leaf and form a thin white border about a millimetre wide. The hyphae are in part aggregated into strands, and consequently the film is at first distinctly radial in structure with a fimbriate margin. On these repent hyphae, short, erect, simple conidiophores, up to 25μ high, are produced at varying distances, usually solitary, but sometimes in pairs, and sometimes three together. The conidiophores bear globose heads of conidia, from 6 to 30μ in diameter. When two or more conidiophores arise close together their heads may fuse into a large continuous mass of conidia, up to 100μ broad. The white patch at first appears pulverulent, owing to the presence of innumerable conidial heads, but ultimately these all coalesce, or sink down to the base of the conidiophores, so that the patch is covered with a uniform waxy-looking layer of conidia.

Groups of conidiophores also break out through the scale and

form small compact patches. The mycelium surrounding the scale grows up over it, and under favourable conditions unites with the erumpent patches to form a film which entirely covers the scale. This covering may be even, or may be elevated in minute tubercles here and there, especially at the margin of the scale.

The hyphae which overrun the scale are densely interwoven into a thin, tough film. They bear conidiophores like those in the marginal film on the leaf, but, as the film is more or less plectenchymatous, these stand closely packed side by side and form a layer resembling the sporodochium of a *Tubercularia*. This layer is at first minutely tomentose, but ultimately it becomes smooth and waxy, owing to the development of conidia and the fusion of the conidial heads.

In some instances the fungus does not spread out over the leaf, but forms a narrow, compact border, even or irregularly pulvinate round the margin of the scale.

The development of the fungus on other species of *Lecanium* is similar to the foregoing, but the mycelium does not appear, in general, to break out on the upper surface of the scale. The film which covers the scale of *Lecanium nigrum*, for example, appears to grow up over it entirely from the margin. In some cases this film can be peeled off.

The fungus is at first white, but finally becomes pale yellow or lemon yellow. In very wet weather it may form a loose mass over the scale, instead of a compact stroma, and this remains permanently white. The same loose growth may occur when scales which bear the yellow stroma are kept in a damp chamber.

The repent mycelium is regular, septate, 1·5–2·5μ diameter. The hyphae coalesce laterally into radial strands.

The majority of the conidiophores are simple, 10–25μ high, 1·2–1·5μ diameter below, tapering upwards more or less regularly to the acute apex. They arise from the repent mycelium, either scattered, or two or three close together, and stand erect or oblique, either straight or slightly curved. In specimens on the more convex scales, *e.g. Lecanium nigrum*, the conidiophores in the film which covers the insect may be more flask-shaped, up to 2μ diameter below, with a comparatively long thin apex.

In addition to the simple conidiophores, there is usually present a varying number of branched conidiophores. These may occur in the film on the leaf, where the conidiophores are scattered, or in the compact layer over the insect. Sometimes the compact film produces a small, white, rather loose tuft, which consists chiefly of branched conidiophores. When, however, clavate tufts up to 0·5 mm. high occur, these generally contain another fungus in addition to the *Cephalosporium*.

The simplest branched conidiophores (fig. 5) have a main stem about 24μ high, with a single lateral branch, arising just below a transverse septum, about 6μ from the base. Others have two opposite branches at about the same height. These might be regarded as branched simple conidiophores, except for the fact that the lower part of the stem is 2μ diameter. Others are 30–36μ, sometimes up to 64μ, high, with a stalk 2·5–3μ diameter below, and two or three whorls of branches, the lower of which may branch again (figs. 6–8). The lateral branches are 10–15μ long, and more flask-shaped than the simple conidiophores, owing to their greater diameter (up to 2μ) and a gradual attenuation towards the base. These larger branched conidiophores have a stumpy appearance. They do not stand out individually above the general level of the fungus.

In culture the branched conidiophores are longer, up to 110μ, with a slender stalk, 1·5μ diameter. They do not bear many whorls of branches, sometimes only one whorl of three branches near the apex, with paired or scattered branches below, sometimes two or three whorls at distances of about 16μ (fig. 9). The lateral branches are up to 12μ long, narrow flask-shaped, 1·2μ diameter. The simple conidiophores in the same culture are 12–24μ long.

The head of conidia is globose and may be from 6 to 30μ in diameter. The conidia are abstricted apically from the conidiophore, but ultimately they are disposed irregularly in the globule. It will be evident that the number of conidia in the head is variable, and not a significant character. They are united by some mucilaginous substance, but there is no excess of this substance between the conidia or round the whole mass. The head is a compact mass of spores without any visible hyaline outer coat. When the fungus is stained with methyl violet, the head stains violet, but the individual spores when separated are hyaline. The mucilaginous substance apparently takes the stain, but on the individual spore it forms such a thin layer that it does not produce any effect. It is soluble in water, and the spores separate when the fungus is mounted in water. In acetic acid the heads remain intact. The conidia are hyaline, narrow-oval or oblong-oval, ends rounded, 2·5–4 × 0·75–1·5μ.

Parkin recorded the occurrence of immature perithecia in one collection of *Cephalosporium Lecanii*. I have not met with perithecia in any recent gathering, and none now remain in Parkin's specimen. It is possible that they may have been perithecia of *Melanospora*.

The fungus grows well on maize-meal agar. On plating out in this medium minute white tufts are produced, each consisting of short hyphae radiating from a central point. These

suberect hyphae soon bear simple conidiophores laterally. On transferring to maize-meal agar slants, a pulvinate mass, 2–3 mm. in diameter, is produced at the point of inoculation, and thence the mycelium spreads over the surface of the slant in a thin film, somewhat tomentose with short projecting hyphae. The fungus is at first white, but in about fourteen days the colour changes to lemon-yellow from the pulvinate centre outwards. Fine strands extend over the glass from the edge of the slant. The agar becomes reddish, or yellowish-red, or orange-red.

The fungus was grown on Raulin's fluid, neutral Raulin (Guéguen), and Naegeli's solution, No. 3, with cane sugar, for comparison with the results of previous investigators.

In Erlenmeyer flasks of Raulin's fluid, the fungus produces minute white spheres up to 2 mm. diameter, the majority of which sink in a day or two to the bottom of the flask. A few may remain floating, and these attain a diameter of 3–4 mm., giving off hyphae which extend over the surface of the liquid and form groups of minute spheres surrounding the parent sphere at a short distance, but all these ultimately sink. The mycelium in this medium is stout, with numerous close-set, spherical or oval swellings. Conidiophores were not observed on the floating spheres; but where the latter adhered to the side of the flask, they formed stromata on the glass which bore conidiophores and conidia. Submerged spheres transferred to Raulin-maize-meal agar slants gave the same growth as that from inoculations with conidia of *Cephalosporium Lecanii* on that medium.

In flasks of neutral Raulin's fluid* white floating islands of mycelium were first produced. These became compact, convexo-pulvinate, up to 5 mm. diameter, and then began to coalesce with one another. After fourteen days the liquid was bordered by an almost complete ring of fused stromata, adherent to the glass, while those elsewhere had united into irregular bands, up to 1 cm. wide, convoluted, rounded above, and elevated in the middle up to 3 mm. above the surface of the liquid. These bands ultimately extended over the greater part of the surface, but they did not fuse into a continuous stroma, the intervening spaces being covered by a thin film of mycelium. The upper surface of these bands was then pale yellow and minutely tomentose; the lower surface became pale yellow, and then

* Neutral Raulin's fluid was prepared in accordance with the formula given by Guéguen in Bull. Soc. Myc. France, XIV (1898), p. 205, viz.:

Distilled water ...	1500	grams.	Magnesium sulphate	0·25	grams.
Cane sugar	70	,,	Zinc sulphate ...	0·07	,,
Neutral potass. tartrate	6·50	,,	Iron sulphate ...	0·07	,,
Ammonium nitrate ...	4·00	,,	Potass. silicate ...	0·07	,,
Ammonium phosphate	0·60	,,			

purple red to blood-red. The stromata at the edge of the liquid in contact with the glass adhered to the latter, as a rule, only by their edges, the remainder of the base being free and irregularly concave; on these the free part of the base was purple-red, and the margin in contact with the glass blood-red with a narrow yellow, external fringe. At the end of twelve weeks, the surface of the liquid was not covered by a continuous stroma.

In flasks of Naegeli's solution No. 3, with 5 per cent. cane sugar (Dop), similar minute floating islands of mycelium were produced. Some of these became 5 mm. in diameter, but the majority did not exceed 1–2 mm. The larger were feebly pulvinate. Hyphae spread out from these stromata over the surface of the liquid, uniting the whole by a very thin, transparent film. The stromata were at first white, finally pale yellow. The film did not thicken up to form a continuous opaque layer. At the end of twelve weeks the individual islets were still distinct, but they were united by a copious submerged weft of mycelium.

The flasks employed for the foregoing cultures were 7 cm. in diameter at the level of the liquid.

Tubes of Raulin agar did not solidify at Peradeniya. Growth on this medium resembled that in flasks of Raulin's fluid, minute white spheres being formed which sank into the medium. Some spheres which adhered to the side of the tube at the surface of the liquid formed minute white stromata which bore conidiophores and conidia. As the medium dried out, more spheres became adherent to the glass, and these ultimately became yellow, the reverse being pale purple-red or orange, with a yellow margin.

On slants of neutral Raulin agar the fungus made a limited growth. At the end of a fortnight a flattened-pulvinate, convoluted stroma had been formed, up to 2 cm. long, 1·5 cm. thick, and 3 mm. high, with a subvertical margin. A slight marginal growth, for a distance of 3–4 mm. over the surface of the agar, occurred later, but the convoluted stroma did not alter, and the fungus did not spread indefinitely over the medium. The colour of the stroma was at first white, becoming lemon-yellow. The reverse was deep orange-red, but the agar was not coloured.

On slants of Naegeli agar with cane sugar a small pulvinate stroma was formed at the point of inoculation, and thence the mycelium spread over the medium in a thin, pulverulent layer. Growth was poor, a patch about 2 × 1·5 cm. being produced in a month. This became pale yellow, with a broad, white, fimbriate margin, the reverse being orange-red, or orange-red in the centre with a yellow margin. The agar was not coloured.

On Dox's agar, with cane sugar and sodium nitrate, a circular, flat, rather compact patch was produced, slightly yellow in the

centre. The reverse was pale orange, becoming dull orange at the end of a month.

On all these media growth was evident to the naked eye in forty-eight hours. The cultures were held at room temperature, which during this period varied from 73° to 81° F. Conidia were produced in all cases, except on submerged growths. No yeasts were observed in any case.

Growth was more vigorous on sterilised potato than on sterilised carrot. On potato a thick, compact, white stroma was formed, covering the whole substratum and ultimately becoming lemon yellow and pulverulent. On carrot the fungus formed a loose, irregularly pulvinate stroma, which exhibited a tendency to grow out in processes, but extended over only half the area of the growth on potato; this ultimately became pale yellow.

Thus *Cephalosporium Lecanii* grows well on maize-meal agar and on neutral Raulin fluid with or without agar, though on the latter the growth is peculiarly limited, and thick, definite stromata are formed. On Naegeli agar the growth is poor, while on Raulin's fluid submerged growths are produced. The yellow colour of the fungus is more intense in culture than in nature.

On maize-meal agar the mycelium in the agar consists of stout hyphae, 3–4μ diameter, with thinner lateral branches down to 1μ diameter. The stout hyphae have walls up to 1μ thick, and bear frequent pyriform or oval swellings up to 6μ diameter (fig. 10). The swellings occur on one side of a septum, but not at all the septa. These hyphae are constricted at the septa. Lateral branches of these hyphae may be of the same character, or they may be regular, 2μ diameter, giving off finer branches 1μ diameter. These branches arise just below a septum, or from a swelling. All the mycelium is septate, the stouter hyphae more closely than the others. In young cultures the septa are 15–25μ apart; in old cultures the stroma consists chiefly of moniliform hyphae, with segments globose, 4–8μ diameter, or oval, up to $9 \times 6\mu$. Abnormal conidiophores frequently arise from the terminal cell of a chain (fig. 11). In old cultures there appears to be a concentration of cell contents in some of the cells of the coarser hyphae; these cells have dense contents, while the other cells of the same hypha are empty.

B. *Hyalopus Yvonis* Dop.

Specimens of a fungus attacking *Aspidiotus perniciosus* on coconut leaves in Martinique were received by Dop in France and were described by him in 1905 under the name *Hyalopus Yvonis*. His description gives the mycelium as hyaline, not septate, repent, not very abundant, forming small grey patches:

the conidiophores erect, not septate, unbranched, terminated by a mucilaginous sphere containing conidia regularly arranged; the conidia hyaline, oblong, $4 \times 1–1{\cdot}5\mu$. The conidia multiplied by budding. I have not been able to ascertain whether a type specimen of this fungus exists.

Dop further stated that when the scale was detached from the leaf, it was found to be filled with hyphae and budding conidia (yeast cells), especially the latter. Some conidia were still enclosed in a mucilaginous sphere, but others were free, the sphere having been dissolved in the moist atmosphere in which the leaves were kept. Mycelium bearing the conidiophores radiated from the scales, but in the bodies of the dead insects he was unable to observe mycelium; they contained only the budding yeast cells. The latter were identical in shape with the conidia, but smaller. Dop considered that he had established, by cultures and infection experiments, that these yeast cells were a form of the *Hyalopus*.

Dop stated that pure cultures were readily obtained by passing a flamed needle lightly over the mycelium or under a scale. He cultivated the fungus on agar with Naegeli's solution plus 5 per cent. sugar, potato, bean agar, pumpkin agar, etc. Inoculations were made with conidia.

On agar with Naegeli's solution and sugar, the fungus, after eight to ten days, formed a smooth orange-yellow crust, which at first consisted entirely of budding yeast cells, identical with those observed in the body of the insect. When the medium began to be exhausted, short filaments appeared. The orange-red (*sic*) colour in these cultures was attributed to the presence of glucose.

Cultures on potato were similar to the foregoing.

In cultures on bean agar and pumpkin agar, neutral or acidified, growth was very slow and no pigment was produced. On peptonised media the development was still more feeble.

Good growth was obtained in a bouillon made by boiling specimens of *Aspidiotus nerii* in Naegeli's solution. The mycelial form developed very rapidly, and in eight to ten days the culture showed a strong development of interwoven hyphae, greyish in colour.

Dop specifically stated that in certain media (agar with glucose, potato), the fungus behaved as a yeast, while in other media (exhausted media, insect bouillon), it produced hyphae. He did not record that he transferred the yeast from potato to insect bouillon, and thereby converted it into a Hyphomycete, nor did he give any details concerning the source of his infection material in his various cultures. Further, he did not mention whether the hyphae in any of his cultures produced conidio-

phores and conidial spheres or not. It would seem not unfair to deduce that they did not.

Infection experiments were made by Dop on *Aspidiotus nerii*. These were successful only with the yeast form, that from cultures on potato being the most virulent. The fungus was inserted beneath the scale, and the inoculated insects were kept in a saturated atmosphere at a temperature of about 30° C. At the end of four or five days, the colour of the scale changed to brown and the insect died. In some places hyphae were produced, but conidiophores were not obtained.

The following would appear to be the probable interpretation of these results. Yeasts occur commonly in these insects, and an extensive literature relating to them is now available, dating back to 1854. Zimmermann (1901) observed them in *Lecanium viride*, and from his account it would appear that he found them universally in that insect. If material for inoculation was obtained by passing a needle under a scale, it is most probable that a culture of one of these yeasts would result.

Again, it is very difficult to secure pure cultures of one of these scale insect Hyphomycetes by simply touching the conidiophores with a needle. As the conidiophores in this case are only about 20μ high, the margin of safety is very small. The repent mycelium entangles spores of numerous leaf-inhabiting fungi, in addition to spores of common moulds and species which grow on dead scales; and if that is touched contamination is almost inevitable. Plating is essential in order to separate the insect fungus from *Pestalozzia, Cladosporium, Fusarium*, etc., especially as these grow more rapidly than the former.

It would seem probable from Dop's account that the grey mycelium obtained in culture was that of a *Cladosporium*. In any case there is no evidence that it belonged to the *Hyalopus*. The hyphae which developed from the scales which died after inoculation with the yeast may have arisen from any chance fungus spores which happened to have lodged round the insects. Scale insects usually die when kept in a saturated atmosphere in a closed glass dish.

While Dop's article was in the press Guéguen published his account of *Acrostalagmus coccidicola*. Dop stated that the latter species differed from *Hyalopus Yvonis* in its colour, its branched conidiophores, and the absence of budding in the conidia. His conclusions with regard to the last point were doubtless founded on erroneous observations. There would appear to be scarcely any room for doubt that *Hyalopus Yvonis* is morphologically identical with *Cephalosporium Lecanii*.

C. *Cephalosporium* (*Acrostalagmus*) *coccidicolum* Guéguen

In 1904 Guéguen described, under the name *Acrostalagmus coccidicola*, a fungus which he had found on a coccid on the leaves of a shrub (? *Mikania*). The mycelium formed a film, egg-yellow in colour, round the body of the insect and extended in radiating hyphae over the surface of the leaf. A translation of his description of the fungus is as follows:

Mycelium floccose, anastomosing, white, then egg-yellow, sparingly septate, 3μ diameter. Fertile hyphae caespitose, erect, scarcely exceeding 3μ in diameter, cylindric, attenuated at the apex, sparingly septate; lateral branches scattered, simple, acute, subsolitary, alternate, or subternate. Conidia cylindric, with rounded ends, hyaline, smooth, mucilaginous, pale yellow, $4–5 \times 1\mu$, forming a spherical globule which soon collapses.

I am informed that no type specimen of this species exists.

Guéguen cultivated the fungus on Raulin's fluid, potato, and carrot, the cultures being held at room temperature, 15 to 18° C. On Raulin's fluid, at the end of a week, a thick, densely-felted crust was formed, yellowish white and farinaceous-fibrillose above, bright yellow and woolly below; the mycelium was so compact that the tubes and flasks containing the cultures could be turned upside down without spilling the liquid.

On potato isolated tufts were formed, velvety and creamy white. On carrot the fungus grew more rapidly, and the mycelium extended over the surface in a large, yellow, velvety band, bearing abundant conidia in the centre, and bordered by a delicately cottony, pure white cushion; the colour finally became sulphur-yellow or lemon-yellow.

Guéguen remarked that in all the cultures the colour of the fungus was paler than in nature, the natural colour being gamboge-yellow or egg-yellow. He attempted to infect an undetermined coccid on Oleander by applying the spores to the insect with a brush, but without success.

Guéguen's small-scale figure shows an apparent conidiophore, with lateral branches, opposite, or solitary and scattered. This is similar to what first appears in plate cultures of *Cephalosporium Lecanii*, and it is probably only a hypha with simple lateral conidiophores. Under natural conditions these hyphae are repent on the leaf, but in the saturated atmosphere of a Petri dish they stand suberect. Guéguen's figure on a larger scale is apparently a conidiophore from a culture.

Guéguen obtained his fungus from a shrub, which it was suggested was a *Mikania*, in a greenhouse at the Paris Exhibition of 1900. The origin of the shrub was not recorded, but if the suggested identification was correct, it may have come from America.

According to the description *Acrostalagmus coccidicola* does not differ morphologically from *Cephalosporium Lecanii*; but biologically it differs in its growth on Raulin's fluid, its more luxuriant growth on carrot than on potato, and its paler colour in culture than in nature.

Dr C. Spegazzini has kindly forwarded me a specimen of a *Cephalosporium* on *Pulvinaria* sp. on *Citrus deliciosa* from La Plata; and cultures of this have been obtained at Peradeniya. The fungus does not differ appreciably from *Cephalosporium Lecanii* in morphological characters. It has compound, as well as simple conidiophores, and on the former can be assigned to *Acrostalagmus*.

On maize-meal agar the growth of the Argentine species is more fluffy than that of *Cephalosporium Lecanii*; it remains white longer, becomes only pale yellow, and does not colour the agar. The reverse is yellow, becoming olive here and there.

In flasks of Naegeli solution, or on slants of Naegeli agar, the behaviour of the Argentine form was similar to that of *Cephalosporium Lecanii*, except that, on the slants, the colour of the upper surface of the stroma was paler.

In flasks of neutral Raulin solution growth was again similar to that of *Cephalosporium Lecanii*, the same irregular convoluted bands being formed. The reverse of these stromata was, however, yellow at first, ultimately becoming olive.

On slants of neutral Raulin agar, a limited cushiony stroma was produced at first, but further growth occurred until almost the whole slant was covered. The stroma became yellow and exuded drops of a brown liquid. The reverse was yellow at first, but became olive, and the agar was coloured a muddy brown.

In flasks of Raulin solution growth was even better than on neutral Raulin. Of the same character at first, growth continued until the surface of the liquid was covered by an irregularly pulvinate layer, with a broad, thick, irregularly pulvinate border extending along the glass. The colour remained white or very pale yellow, the reverse being yellow to olive.

On slants of Raulin agar the growth was again vigorous, covering the medium with a thick cushiony stroma, sporiferous in a band down the middle, with stout swollen margins. The colour of the stroma was yellow, the reverse being yellow, then olive, and finally yellow-brown, while the agar was coloured yellow-brown.

On Dox's agar growth was similar to that of *Cephalosporium Lecanii*, the stroma being rather more deeply coloured pale yellow above. The reverse was pale yellow, becoming yellow to greenish-yellow at the end of a month.

On both sterilised potato and sterilised carrot the growth was thick and cushiony, and ultimately pale yellow. Growth on potato was better than on carrot, the mycelium in the former case spreading from the potato over the sides of the tube.

Thus the Argentine fungus differs from *Cephalosporium Lecanii* in its luxuriant growth on Raulin's fluid, the different colour of the reverse of the culture on neutral Raulin's fluid or neutral Raulin agar, the coloration of neutral Raulin agar, and the lack of coloration of maize-meal agar. It is usually of slower growth at first than *Cephalosporium Lecanii*, the mycelium not being visible until the fourth day.

On the other hand, the Argentine fungus agrees with Guéguen's account of *Acrostalagmus coccidicola* in its growth on Raulin's fluid, the initial colour of the reverse on that medium, and its paler colour in culture than in nature. It differs in that the growth on carrot is not better than the growth on potato, as far as regards Ceylon samples of these vegetables.

On the whole, it would appear that the Argentine fungus is the same as *Acrostalagmus coccidicola*; and that while this species does not differ from *Cephalosporium Lecanii* morphologically, it does differ biologically.

The question arises whether these species should be referred to *Hyalopus*, *Cephalosporium*, or *Acrostalagmus*. Guéguen, in his paper on *Acrostalagmus Vilmorinii*, described that species as producing simple, as well as branched, conidiophores, and stated that the varied form of its conidiophores gave him cause for hesitation in classifying it generically. He noted that the genus *Hyalopus* differed from *Acrostalagmus* only in its simple conidiophores, and that Parkin and others had placed in *Cephalosporium* species which did not differ from *Hyalopus*.

Guéguen considered that the difference between *Acrostalagmus* and *Hyalopus*, *i.e.* "the more or less regular arrangement of the conidiophores round the axis which supports them," was not sufficient to maintain the two distinct. His *Acrostalagmus coccidicola* frequently produced, especially in the early stages of a culture, simple conidiophores corresponding to *Hyalopus*, and he considered that it was probably these which Dop had described as *Hyalopus Yvonis*, a species which appeared to be identical with *Acrostalagmus coccidicola*.

Guéguen concluded that the genus *Hyalopus*, and possibly also the genus *Cephalosporium*, should be discarded, their several species being placed in *Acrostalagmus* if their conidia were mucilaginous, or in *Stachylidium* if their conidia were pulverulent.

Guéguen's statement regarding the difference between *Acrostalagmus* and *Hyalopus* was probably based on observations on

the repent hyphae, bearing scattered simple conidiophores, which become suberect in culture, and mimic compound conidiophores. The difference really is between the simple conidiophores of *Hyalopus*, and the compound, regularly branched conidiophores of *Acrostalagmus*. The fact that both forms may occur in some species would not necessarily be a sufficient reason for combining the two genera.

Parkin noted that *Cephalosporium Lecanii* had mucilaginous conidial heads, and on that character should rather be referred to *Hyalopus*. *Hyalopus*, however, is supposed to have heads which consist of a large globule of mucilage, in which the spores float free from one another for the greater part. In *Cephalosporium Lecanii*, as already stated, no such excess of mucilage has been observed.

Lindau, discussing *Hyalopus Populi*, stated that in culture in a damp atmosphere it produced spherical heads in which the conidia were bound together by mucilage, but in a dry atmosphere the conidiophores bore only separate conidia united loosely into a head. In the latter case, the fungus did not differ in the slightest degree from *Cephalosporium*, and hence he was of opinion that *Hyalopus* was only a *Cephalosporium* grown under moist conditions.

Buchanan discussed the relationship of *Hyalopus* and *Cephalosporium* in a paper on *Cephalosporium Pammelii*. He found that the spores of that species were mucilaginous, but in a dry atmosphere only sufficient mucilage was produced to cause the spores to adhere to one another. In a moist atmosphere the globule of mucus swelled until its volume was three to four times that of the mass of spores, and the individual spores floated free in the liquid. Consequently, he agreed with Lindau that *Hyalopus* should be merged in *Cephalosporium*.

The fungus studied by Buchanan ultimately formed septate conidia. Hence it would appear that it was similar to the conidial stage of certain species of *Nectria*, in which first a *Cephalosporium* and then a *Fusarium* is produced. In hanging-drop cultures of such species, *e.g. Nectria haematococca*, the *Cephalosporium* spores may frequently be found floating free in a drop of liquid at the apex of the conidiophore, though I have only observed this when the drop was in contact with the cover-glass.

There is thus general agreement that *Hyalopus* should be merged in *Cephalosporium*. The two genera appear to have been instituted at the same time, *Hyalopus* having page priority. But the name *Cephalosporium* has been more generally adopted, and for that reason should be retained.

Acrostalagmus differs from *Cephalosporium* in having branched,

instead of simple, conidiophores. The separation would appear to be a convenient one as far as perhaps the majority of species of *Cephalosporium* are concerned, though there undoubtedly are species which have both simple and branched conidiophores. *Acrostalagmus* is prior to *Cephalosporium*.

As regards the scale insect species, these have both simple and branched conidiophores. But most of the conidiophores are simple, and there would be no advantage in placing them in *Acrostalagmus*, where they would seldom be looked for. Perhaps the simplest course is to leave them as *Cephalosporium* (*Acrostalagmus*) *Lecanii*, and *Cephalosporium* (*Acrostalagmus*) *coccidicolum* respectively. If biological species are not admitted the former name has priority.

D. *Cephalosporium* (*Acrostalagmus*) *longisporum* Petch.

In 1916 a *Cephalosporium* was found in Ceylon on *Icerya purchasi*, the fluted scale, which had recently been introduced into the island. It was recorded at the time as *Cephalosporium Lecanii*, but it has larger conidia than that species. It occurred alone, or in company with a *Melanospora*.

The fungus spreads from the insect over the surrounding bark, and forms a border round it up to 3 mm. wide, at first white, then sulphur-yellow. It also overruns the insect and turns it yellow, but it is difficult to detect among the curled waxy filaments which cover the insect, and the latter appear to become yellow, in part, naturally, independently of any fungus attack.

The yellow border is byssoid, more coarsely fibrillose than that of *Cephalosporium Lecanii*, and usually radially ridged, the ridges broadening slightly towards the outer edge and terminating in a thick brush of hyphae. These ridges are covered with short erect conidiophores, bearing globose heads of conidia.

The mycelium is about 2μ diameter, hyaline and septate. The simple conidiophores are up to 24μ high, usually 1–$1{\cdot}5\mu$ diameter at the base, tapering uniformly to the apex, but sometimes shorter, 12μ high, $2{\cdot}5\mu$ diameter at the base, tapering regularly to about two-thirds their height and thence continued as a thin sterigma. They may be straight or curved.

With these occur branched conidiophores, with a stem $1{\cdot}5\mu$ diameter, bearing one or two whorls of branches. The branches are up to 12μ long, elongated flask-shaped, $1{\cdot}5\mu$ diameter below, tapering uniformly to about 8μ and terminating in a fine point about 4μ long. In some cases the branches may be inflated to 2μ at the base and consequently appear more flask-shaped.

The heads of conidia are up to 30μ diameter, but generally smaller, up to 16μ. The conidia are oblong-oval, sometimes

attenuated to one end, or subclavate, with one end sometimes subacute, 6–12 × 1·5–2·5μ.

The insect occurs principally on *Acacia decurrens* in the hill districts of Ceylon. In January, 1924, specimens of the fungus being required for cultivation, the plant collector was sent up to Hakgala with instructions to collect twigs of *Acacia* bearing yellow specimens of the insect. In this he was unsuccessful, but brought down living examples of the insect on *Acacia decurrens*. These on receipt (January 8th) were placed in a large glass dish with a loosely-fitting cover. The young insects, about 0·6–1 mm. long, very soon deserted the old insects and the *Acacia* branches and congregated in hundreds on the side of the dish facing the light. On January 16th it was noticed that nearly all these young insects were attacked by a fungus, and on examination this proved to be the large-spored *Cephalosporium*.

The fungus on these young insects, and in the saturated atmosphere of the glass dish, formed loose, whitish tufts of hyaline hyphae. These hyphae bore simple conidiophores, up to 24μ high, and, in addition, tall *Acrostalagmus* conidiophores. The latter were up to 110μ high, 2μ diameter at the base, septate, usually with two whorls, each of three branches, the one near the apex making, with the terminal segment of the main axis, a group of four branches. The branches were usually long, up to 30μ, 1·5μ diameter below, tapering uniformly to the apex. In one instance a conidiophore forked below into two branched conidiophores, the total height of the whole being 180μ. Irregular conidiophores were not uncommon. One, 70μ high, had a pair of opposite branches at a height of 30μ and a single branch at 50μ. Another conidiophore had a whorl of three branches, of which one was 30μ long, and the other two about 8μ long.

The heads of conidia on the branches of the larger conidiophores are usually small, ovoid, 8–10μ diameter, and the conidia are arranged in them in a parallel bundle, side by side, not irregularly as in the larger heads on the simple conidiophores.

On maize-meal agar the fungus forms at first a flat white circular stroma, narrowly concentrically zoned. The heads of conidia are large and consequently the stroma presents a "crystallised" appearance instead of the powdery appearance of *Cephalosporium Lecanii*. After a few weeks the central part develops white tufts of mycelium and becomes thicker and woolly, though still remaining flat; and finally the stroma becomes pale yellow from the centre outwards. The agar is slightly reddened.

On Dox agar growth is limited, a compact convoluted stroma being formed, pale yellow to white in colour. The reverse is orange and the agar is not coloured.

On Naegeli agar growth is equally limited, the stroma being flat, slightly woolly tomentose, pale yellow in the centre, with a white margin. The reverse is orange-yellow, becoming yellow-brown, and the agar is not coloured.

On neutral Raulin agar a thick, convoluted stroma is formed, larger and thicker than on the two previous media, but much less extensive than on maize-meal agar. It becomes sulphur-yellow, more deeply coloured than on the other media, with a white margin, and with the reverse yellow to orange-yellow. The agar is not coloured.

Apparently the same species has been collected on an aphis at Peradeniya. In these specimens the fungus covers the body of the insect and spreads out in rather coarse strands along the legs and over the leaf. The central part of the stroma is ultimately covered with pale yellow masses of conidia, which may fuse into a continuous waxy sheet, while the spreading mycelium in the available specimens is white. Both simple and compound conidiophores are present, the former 16–32μ high, 1–2μ diameter at the base, and the latter up to 36μ high, 2μ diameter below, with a single whorl of branches. The conidia measure 6–10 × 1·5–2μ. As the only available specimens were collected ten years ago, it has not been possible to run parallel cultures of this form on *Aphis*. Consequently, it may not be biologically equivalent to the fungus on *Icerya*. Morphologically, however, the two are identical.

As already stated, a *Melanospora* occurs on *Icerya purchasi* on *Acacia decurrens* in Ceylon. Whenever the insects are found to be attacked by *Cephalosporium longisporum*, a large percentage, usually 50 per cent. or more, bear the *Melanospora*, in addition to the *Cephalosporium*. In a few cases the insect appears to bear the *Melanospora* only, *Cephalosporium* conidiophores not being evident; but these insects are covered with yellow mycelium which is probably that of the *Cephalosporium*.

The *Melanospora* agrees in all details with *Melanospora parasitica* Tul. The basal part of the perithecium is reddish-brown, spherical, 0·15–0·2 mm. diameter, with a cylindrical ostiolum, up to 1 mm. high, 50μ diameter below, tapering to 20μ diameter above, blackish-brown below, becoming paler above. The spores are cylindric, with truncate ends, becoming more barrel-shaped in culture media, 5–8 × 2–2·5μ. The weft of mycelium at the base of the perithecium is composed of regular, distinctly septate hyphae, 3μ diameter, with a rather stout wall which appears yellowish under a high magnification.

De Bary stated that *Melanospora parasitica* had a conidial stage consisting of short, verticillately-branched hyphae, with whorls of secondary branches from which the conidia were

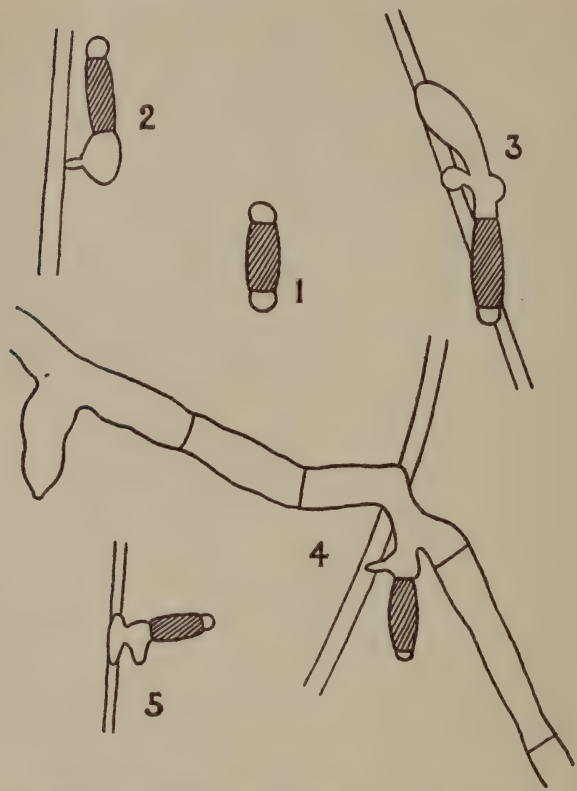
abjointed acrogenously and serially, but that it was very rarely produced. Nothing of that description has been observed in the present investigations, except *Spicaria javanica*, which shows no evidence of being related to *Melanospora*. Berlese found that *Melanospora globosa*, described from specimens on decaying herbaceous plants and fragments of wood, had an *Acrostalagmus* conidial stage, which he considered to be *Acrostalagmus albus* Preuss. Consequently, it is of interest to determine whether the *Cephalosporium* (*Acrostalagmus*) found on *Icerya* is related to the *Melanospora* which so generally accompanies it.

Cultures on maize-meal agar started with *Cephalosporium* conidia do not produce *Melanospora* perithecia. That is the case, whether single spore colonies are transferred to maize-meal tubes, or whether several colonies are allowed to grow on the same plate until they meet.

The spores of *Melanospora* are extruded when mature and form first a globule and then a powdery mass at the apex of the ostiolum. Spores taken from the ostiola of perithecia on the insect, which had been extruded for some days, did not germinate in hanging drops or films of water, maize-meal agar, or Dox agar, in damp cells. Spores taken from the ostiola of perithecia in culture, when first extruded and in a globule, germinated in similar maize-meal agar films; but others taken from the same culture, after the masses of spores had become powdery, did not germinate under the same treatment. When, however, the film in the latter case was allowed to dry, and re-wetted twenty-four hours later, some of the spores germinated. In all cases, the spores produced a hemispherical, or subglobose, hyaline protuberance at each end, but no further growth resulted. When two spores happened to lie with their ends almost in contact, their hyaline protuberances fused with one another.

When spores of *Melanospora* were plated on Dox agar or maize-meal agar, no growth was visible to the naked eye.

Cephalosporium spores and *Melanospora* spores were sown on opposite sides of maize-meal agar films in damp cells. The *Melanospora* spores, obtained from culture, germinated, while the *Cephalosporium* mycelium quickly overran the film. When a *Melanospora* spore was situated near a *Cephalosporium* hypha its hemispherical "germ tube" enlarged, becoming irregularly oval, and put out laterally a slender conical haustorium which attached itself to the hypha. A stout irregular mycelium, 3–4μ diameter, then developed from the enlarged germ tube and ran through the culture, giving off here and there lateral subglobose protuberances which attached themselves to the *Cephalosporium* hyphae. *Melanospora* perithecia were subsequently produced on the films.



Melanospora parasitica Tul. 1, germinating spore; 2, haustorium attacking a *Cephalosporium* hypha; 3, early stage of development of the *Melanospora* mycelium; 4, later stage of the same; 5, expansion of a haustorium within a *Cephalosporium* hypha; all × 1500.

Melanospora perithecia may be obtained in quantity by plating together the conidia of the *Cephalosporium* and the ascospores of the *Melanospora*. The *Cephalosporium* develops first and produces normal zoned colonies, the *Melanospora* perithecia appearing in about ten days. The first *Melanospora* spores from culture used in the foregoing germination tests were obtained accidentally in that way. The hyphae of the *Cephalosporium* ascend the ostiola of the *Melanospora* and produce conidia anywhere along its length. Consequently, in plating *Melanospora* spores from the insect, the *Cephalosporium* may occur as a contamination, and hence the culture produces perithecia later. After repeated transfers on maize-meal agar, the *Melanospora* covers the mixed culture with white mycelium, and the perithecia do not appear until the culture is about a month old.

The foregoing results are in accordance with those obtained by Kihlman with *Melanospora parasitica*, as cited by de Bary and others. I have not been able to consult the original paper. Kihlman found that the *Melanospora* spore germinated by the emission of a germ tube at each extremity, the tubes, whether grown in water or in nutrient solution, being scarcely longer than the transverse diameter of the spore. If the spore was lying against, or on, a hypha of *Isaria*, the germ tube became firmly attached to the hypha of the host and then developed into a mycelium, while if the germ tube came in contact with an older hypha of *Melanospora*, the membrane between them was dissolved and they coalesced with one another.

Zopf described and figured the haustoria of *Melanospora Didymariae*, attacking the paraphyses of *Humaria carneo-sanguinea*, on which it is parasitic.

The precise nature of the attachment of the haustoria of *Melanospora parasitica* to the hyphae of its host fungus does not appear to have been ascertained. The observations made in the present experiments indicate that the haustoria formed by the hyphae in general are different from that formed by the germ tube. The former are subglobose, and are attached to the host hypha over a wide base, or may partly encircle it. The latter is slender, conical, and terminates in a point which is attached to the host hypha, as in the case figured by Zopf.

In one instance after staining with eosin it appeared that the haustorium had penetrated the wall of the host hyphae, and had formed an irregular vesicle inside it, but it has not been possible to carry out further investigations to confirm this.

It is clear from the observations recorded that *Melanospora parasitica* is strictly parasitic on fungi, and in the present case it is parasitic on the *Cephalosporium*, not on the insect.

Cephalosporium longisporum n.sp. Mycelium sulphur-yellow, encircling the host insect with a byssoid, fibrillose stroma up to 3 mm. wide. Hyphae 2μ diameter, hyaline, regular, septate. Conidiophores simple, 24μ high, 1·5μ diameter, attenuated upwards, or branched, up to 110μ high, bearing elongated flask-shaped branches, up to 30μ long, in whorls of three. Conidial heads globose, up to 30μ diameter, or ovoid, 8–10μ diameter. Conidia hyaline, oblong-oval or subclavate, sometimes subacute at one end, 6–12 × 1·5–2·5μ. On *Icerya purchasi*, Ceylon.

E. *Cephalosporium* (*Acrostalagmus*) *coccorum* Petch.

In September, 1920, I collected an *Acrostalagmus* at Hedon and at Aldborough, East Yorkshire, in both cases on *Chionaspis salicis* on Ash. Apparently the same species was again collected on *Lepidosaphes ulmi* on Hawthorn at Hunstanton, Norfolk, on

several occasions from October, 1920, to February, 1921; while Mr E. E. Green sent me specimens from Camberley in November, 1920, on *Lepidosaphes* on Apple.

On *Lepidosaphes* the fungus grows out from beneath the scale and forms a minute, white, rather loose, byssoid patch over the adjoining bark. It may also extend in a thin film over the scale. In the available specimens, it does not form a complete border round the scale, nor does it spread far over the host plant. The patch is minute and inconspicuous.

On *Chionaspis* the fungus similarly grows out in minute tufts from the margin of the scale, but some hyphae, in the specimens collected, run more generally over the whole colony. Consequently, when the conidiophores are developed, extensive patches are covered with a delicate bloom. There is not, however, a conspicuous film of hyphae over these patches.

The hyphae are about 2μ diameter, hyaline, septate. They bear either simple or branched conidiophores. The simple conidiophores (fig. 12) are $12–25\mu$ high, $1{\cdot}2–2\mu$ diameter at the base, tapering uniformly to the apex, or tapering uniformly to about 6μ from the apex and thence continued as a thin sterigma. They are generally continuous, but may have a transverse septum in the lower half. Each conidiophore bears a spherical head of spores, generally small and from 4 to 10μ in diameter, but these may coalesce into spheres $12–16\mu$ diameter. The conidia are hyaline, narrow-oval or oblong-oval, usually with one end subacute, $3–5 \times 0{\cdot}75–1{\cdot}5\mu$, sometimes $6{\cdot}5 \times 2\mu$, generally straight, but sometimes slightly curved (fig. 15).

The branched conidiophores (figs. 13, 14) are up to 120μ high. Some are short with only a single pair of branches. Others, up to 90μ high, have a single whorl of branches in the upper third. The larger have two whorls of branches in the upper half of the conidiophore, with three or four branches in a whorl. The branches are usually $14–16\mu$ long, but on the larger conidiophores they may attain a length of 30μ; they are up to 2μ diameter at the base, and taper uniformly to the tip, but are frequently slightly contracted and rounded at the point of attachment and consequently appear more flask-shaped than the simple conidiophores. The stalk of the conidiophore is septate, and 2μ diameter, or in the larger examples 3μ diameter, at the base.

The globose heads of conidia do not long remain attached to the apices of the branches of the conidiophores. They frequently slip down and form a continuous mass round the main stem in the axils of the branches.

In general structure this species resembles *Cephalosporium Lecanii*. In the latter the simple conidiophores are sometimes

flask-shaped, but in general they are uniformly tapering, as in this species. The spores of the British species are slightly narrower than in *Cephalosporium Lecanii*, and occasionally a few spores occur which are longer (6·5μ) than those usually found in *Cephalosporium Lecanii*.

The principal differences between this species and *Cephalosporium Lecanii* are the colour of the fungus, its mode of growth, and the abundance of comparatively tall *Acrostalagmus* conidiophores. The latter is a very marked feature in comparison with the scarcity and small stature of the branched conidiophores of *Cephalosporium Lecanii*. The "bloom" observable on a colony of *Chionaspis* attacked by this fungus is chiefly due to the presence of numbers of erect conidiophores.

Cephalosporium Lecanii forms a definite conspicuous patch round the scale, and finally covers it with a continuous compact stroma. In the present species only small tufts, or loose byssoid patches, are formed, and the fungus is scarcely visible, especially on *Lepidosaphes*, until the insect is examined with a lens. It might be supposed that this meagre growth is attributable to the lower temperature to which the English fungus is subject, but on the other hand the actual conidiophores are larger than those of *Cephalosporium Lecanii*. *Cephalosporium Lecanii* is at first white, and later becomes yellow. The British species is apparently permanently white. This may perhaps be related to the looser habit of the mycelium; loose growths of *C. Lecanii* are permanently white.

It has unfortunately not been possible to run parallel cultures of this species and *Cephalosporium Lecanii*. Specimens of the former, collected in February, 1921, were brought out to Ceylon in April, but by the time the matter could be taken up the conidia proved to be dead.

I was unable to find any species resembling this under *Cephalosporium*, *Acrostalagmus* or *Verticillium* in Herb. Kew or Herb. British Museum. Corda described and figured *Verticillium minutissimum*, on a very small insect larva, but neither his description nor his figure agrees with the present species.

In 1882 Penzig recorded an *Acrostalagmus* on *Lecanium hesperidum* on lemon in Italy. He stated that the fungus covered the part of the leaf on which the dried body of a *Lecanium* was situated, with a white film. From his figures, which were reproduced in Saccardo, *Fungi Italici*, No. 1194, it would appear that the fungus surrounded the insect in a white, loose and somewhat floccose border, 1–1·5 mm. wide. The conidiophore, as shown in the figure, is erect, with five successive whorls of branches, and up to six branches in a whorl. The branches are long and tapering, and in one instance again

branched. Penzig assigned this species to *Acrostalagmus albus* Preuss, though he noted that there were some slight differences from the original description of the latter. He stated that it often occurred in company with *Verticillium heterocladum*.

Acrostalagmus albus was described by Preuss in *Linnaea*, XXIV (1851), p. 126. The following is the original description, for which I am indebted to the Imperial Bureau of Mycology:

"Caespitibus effusis, tenuibus, sublanuginosis, albis; hyphopodio ramoso, repente, septato; stipite erecto, pellucido, aspero, supra ramuloso; ramulis continuis, verticillatis, ternatis vel sexternis, apice capituliformibus; globulis sporarum globosis albis; sporis numerosissimis minutis ovatis albis. Habitat in ligno nigrescente *Alni glutinosae*. Hoyerswerda."

The description given in Saccardo, *Sylloge Fungorum*, IV, p. 163, is apparently one drawn up by Penzig in 1882. It reads as follows:

"Caespitulis effusis, tenuibus, sublanuginosis, albis; hyphis sterilibus repentibus, continuis v. spurie septatis, paullum ramosis, ramos fertiles 200–220 × 1·7–2 emittentibus; ramis fertilibus ascendentibus v. repentibus, supra ramulosis; ramulis continuis, verticillatis, ternis vel senis, interdum solitariis, alternis, paullum curvatis, apice attenuatis, summa extremitate capitulum gerentibus; capitulis sphaericis, tenuissimis, columella carentibus, caducis, 9–10μ diam., conidia numerosissima foventibus; conidiis minimis, elliptico-oblongis, 3·3–3·4 × 1–1·5μ hyalinis. Hab. in ligno Alni glutinosae Hoyerswerda et in foliis Citri Limonum *Lecanio Hesperidum* infectis in Italia boreali."

Penzig's description and figures do not agree with *Cephalosporium Lecanii*, in which the *Acrostalagmus* form is poorly developed in nature. They do, however, agree with the species collected on *Lepidosaphes* in England, though the mycelium is more abundant and the conidiophores larger. It is to be noted that the conidiophores were either erect or creeping, and that the branches were in whorls or solitary. It is probable that the repent conidiophores were repent hyphae, bearing simple conidiophores. Penzig's fungus would appear to be the same as the English species on *Lepidosaphes*, etc.

On the other hand, it does not appear likely that Penzig's specimen was correctly assigned to *Acrostalagmus albus*. The description of the latter is little more than generic, but the fact that the stalk was rough excludes the scale insect species. Moreover, the habitat, on blackening wood, is opposed to the view that the type of *Acrostalagmus albus* was on a scale insect which the describer overlooked. It is not usual to find scale insects on decaying wood. In all probability *Acrostalagmus albus* is a saprophytic lignicolous species, not an entomogenous species.

Berlese regarded *Acrostalagmus albus* as the conidial stage of *Melanospora globosa*, a saprophytic species.

In the *Gardeners' Chronicle*, LVII (1915), p. 139, Horne described *Cephalosporium Lefroyi* on *Aleurodes vaporariorum*, found on *Centropogon* at Wisley. Specimens of this are not now available. The conidiophores were simple, septate or continuous, fastigiate, with a globose head ± 3·5–7μ diameter. The conidia were hyaline, ellipsoid, ovoid, or oblong, straight or slightly curved, ± 7 × 1–1·7μ. The hyphae were septate, 1·7–3μ diameter, and the fungus white. The dimensions given for the conidia are larger than those of the species on *Lepidosaphes*, though they would fit exceptional spores of the latter. But no mention is made of branched conidiophores in *Cephalosporium Lefroyi*, whereas these are a conspicuous feature in the *Cephalosporium* on *Lepidosaphes* and *Chionaspis*. Moreover, Horne stated that the mode of occurrence of the *Cephalosporium* on the *Aleyrodes* nymph agreed in every respect with Parkin's description and figure of *Cephalosporium Lecanii* on *Lecanium*, which is decidedly not the case in the present species. From these details and the dimensions of the spores, it would appear that the latter species is not the same as *Cephalosporium Lefroyi*. Accordingly, I propose the name *Cephalosporium* (*Acrostalagmus*) *coccorum* for it.

Cephalosporium* (*Acrostalagmus*) *coccorum n.sp. Mycelium septate, regular, hyaline, 2μ diameter, forming minute white patches at the side of the scale, or a thin film over it; conidiophores simple, 12–25μ high, 1·2–2μ diameter at the base, tapering upwards uniformly, continuous or septate; or compound up to 120μ high, 2–3μ diameter, septate, bearing tapering branches, 14–30μ long, 2μ diameter, in whorls of three or four; conidial heads globose, 4–10μ diameter; conidia hyaline, narrow-oval or oblong-oval, usually with one end subacute, usually straight, sometimes slightly curved, 3–5 × 0·75–1·5μ, rarely 6·5 × 2μ. On *Lepidosaphes ulmi* and *Chionaspis salicis*, England.

F. *Spicaria javanica* Bally.

In July, 1922, specimens of a *Ceroplastes* on *Santalum album*, which were attacked by *Cephalosporium Lecanii*, were collected in the Botanic Gardens, Peradeniya. An attempt was made to start a culture of the *Cephalosporium* by transferring spores directly from the insect by means of a platinum needle. The tubes inoculated proved in all cases to contain fungi other than the *Cephalosporium*, *e.g. Cladosporium*, *Pestalozzia* and *Spicaria*. Examination of the scale insects showed that the *Spicaria* occurred on them, intermingled with the *Cephalosporium*. The

same *Spicaria* has also been obtained on plating out *Cephalosporium* spores from *Lecanium viride* and *Icerya purchasi*, and it has been found on *Lecanium viride*, on caterpillars of *Euproctis flava*, and on egg masses of *Homona coffearia*. On *Lecanium viride* it occurred when scales attacked by *Cephalosporium Lecanii* were kept in a closed glass dish, forming minute, pulverulent, violet-grey tufts. On the caterpillars of *Euproctis* it formed loose white masses, covering the insect and spreading over the leaf; these masses remained permanently white, but in culture the same violet-grey colour was produced as in the *Spicaria* from *Lecanium*, *Icerya* and *Ceroplastes*.

It may have been this fungus, or that next described, of which Parkin saw the conidia in chains when specimens of *Lecanium* attacked by *Cephalosporium Lecanii* were kept in a damp chamber. Cultures show that it is not related to the *Cephalosporium*.

On maize-meal agar (in tube culture) this *Spicaria* forms small pulvinate masses, which are united at first by a rather scanty growth of mycelium. Numerous erect delicate conidiophores are produced, which tend to be aggregated in small tufts. As growth proceeds a thick continuous layer is formed, consisting chiefly of masses of conidia, the surface being irregularly nodular. The reverse now shows a continuous felted layer of mycelium, irregularly wrinkled, at first pale yellow in colour, becoming ochraceous. This mycelium lies chiefly in the agar. The mass of spores is white at first, but ultimately becomes violet-grey. When the culture is old, the growth collapses into an even stratum consisting principally of spores.

The margin of the culture, along the edge of the slant, is white and fimbriate. As the culture ages hyphae grow out from the margin over the surface of the glass in white strands up to 0·2 mm. broad, which divide and anastomose. These extend over the glass until the strands from the two sides meet. Conidiophores are produced along these strands.

In some tubes erect white clavae, up to 1·3 cm. high, and 1 mm. diameter below, arise from the surface of the culture, usually in the lower half, when it is old.

On neutral Raulin agar growth is more vigorous than on maize-meal agar; the slant is soon covered with violet-grey masses of conidia, and within three weeks there is a copious growth of strands of mycelium over the sides of the tube; the colour of the reverse is orange to orange-red. On Raulin agar the growth is good, but strands do not appear so early as in the previous case, and the reverse is yellow to orange-yellow. On Naegeli agar with cane sugar the growth is poor; the reverse of the culture is pale orange.

On gelatine the reverse is yellow to orange-yellow. The gelatine is not liquefied.

On Dox agar the reverse is orange. The agar is not coloured.

On sterilised potato growth is good, the substratum being covered with violet-grey masses in a week. Growth on sterilised carrot is slower.

The colour of the masses of conidia was the same in all the cultures, the only difference observable being a slightly deeper tint in the culture on carrot.

Grown on films of maize-meal agar in damp cells, the conidiophores (fig. 16) are about 1 mm. high, and bear branches in whorls in the upper half or two-thirds, distant in the lower part, but crowded above and sometimes forming a loose head. The stalk of the conidiophore is septate, and $1{\cdot}5\mu$ diameter. The lateral branches (fig. 17) are short and stouter than the stalk, slightly inflated or oval, 4μ long and $2{\cdot}5\mu$ diameter, and bear at their apices oval basidia, acute above, 4–6μ long and 2–$2{\cdot}5\mu$ diameter. The lateral branches may occur singly, or in whorls of two to six, and the apex of a branch may bear from one to six basidia. In some cases the basidia arise in whorls directly from the main stem of the conidiophore. The spores are borne at the apices of the basidia in chains, in which, under a high magnification, the immature spores appear as if joined by short links. The latter effect appears to be due to the attenuation of the ends of the immature spore. The spores are narrow-oval, 3–$4 \times 1{\cdot}2$–$1{\cdot}5\mu$, with ends rounded or subacute. The mycelium is hyaline, septate, $1{\cdot}5\mu$ diameter, with lateral branches which diminish to a diameter of $0{\cdot}75\mu$.

Zimmermann (1901) recorded a second Hyphomycete on *Lecanium viride*, which he referred to as "the fungus of Gierlings," after its discoverer. He stated that it could be distinguished from *Cephalosporium Lecanii* by the naked eye, as it forms much thicker masses round the scale. His figure shows a ring of minute pulvinate masses in contact with one another at the margin of the scale, but this appearance is not uncommon in the case of scales attacked by *Cephalosporium Lecanii*. The conidia were borne in chains at the ends of repeatedly branched hyphae. The dimensions of the conidia were not given and Zimmermann did not name the fungus.

Zimmermann gave three figures, two of which were said to show young conidiophores, while the third is that of an old conidiophore. The third would pass well for a single branch of the Ceylon *Spicaria*: it shows three chains of conidia, each arising from a basidium, situated at the apex of a short branch. The other two figures show branching chains of narrow-oval cells, which produce smaller narrow-oval cells at the septa, the

latter cells bearing at their extremities one or two chains of conidia directly, *i.e.* without basidia. Nothing resembling these two figures has been observed in the Ceylon *Spicaria*, and it does not seem probable that they are related to the species of the third figure.

Bally, in 1923, described under the name *Spicaria javanica* a fungus which occurred on the beetle, *Stephanoderes hampei*, in coffee berries in Java. The hyphae were sparingly septate, white. The conidiophores were profusely branched, very variable in length, 1–2μ diameter, bearing towards the apex numerous branches in whorls. The lateral branches bore at their apices three or four secondary branches (basidia) and from the ends of these arose long chains of conidia. The apex of the stalk of the conidiophore also bore three or four basidia. The conidia were oblong, 2×1–$1{\cdot}5\mu$, at first white, then violet-grey.

In cultures on potato antler-like coremia, 1–3 cm. high, were produced in three or four weeks. These were smooth, dark yellow below, whitish grey at the apex.

Bally's figures show short lateral branches, oval or inflated, broader than the stalk of the conidiophore, and narrow-oval basidia. In these respects his fungus resembles the Ceylon *Spicaria* on *Ceroplastes*, but the apex of the basidium is figured obtuse, and the conidia in the chains have obtuse ends in contact.

Notwithstanding the differences in the figures and the recorded measurements of the conidia, it would appear most probable that the Ceylon fungus on *Ceroplastes*, etc., is *Spicaria javanica*.

Johnston, in 1918, described *Spicaria Aleyrodis*, on *Aleyrodes variabilis* on *Carica papaya*, in Cuba. The conidiophores were hyaline, frequently branched above, with branches in whorls. The lateral branches were short, branching again, and bearing two to four flask-shaped basidia at their apices. The conidia were elliptic or oval, or more or less cylindric, hyaline, $1{\cdot}6 \times 3{\cdot}3\mu$. In the dimensions of the conidia, this species approaches the Ceylon *Spicaria*, and it also resembles the latter in its short, oval, lateral branches, but it differs in its flask-shaped basidia, as described and figured by Johnston. I have not seen a specimen.

G. *Gonatorrhodiella coccorum* Petch.

The stromata of *Cephalosporium Lecanii* on *Lecanium viride* sometimes bear minute erect clavae up to 0·5 mm. high. On plating out conidia from these clavae one obtains, in addition to, or instead of, the *Cephalosporium*, a fungus which in some respects resembles a *Gonatorrhodiella*. The clavae usually contain

the hyphae and conidiophores of both fungi. The hyphae of the *Gonatorrhodiella*, as far as they can be distinguished in the clava, resemble long conidiophores with a single lateral branch curving upwards more or less parallel to the main hypha.

This *Gonatorrhodiella* has been found alone on a black *Aleyrodes* on mango, on which it formed a delicate loose white border at the margin of the scale, *i.e.* on the insect, not on the leaf.

On *Aleyrodes* the conidiophores (fig. 18) are up to 0·2 mm. high, lax, suberect, hyaline, septate at close intervals (4–6μ), and 1·5–2μ in diameter. The terminal segment is ovato-conoid, or lanceolate, inflated to a diameter of 3μ, with an obtuse or an acuminate tip. The conidiophores bear chains of spores, arising singly from sterigmata which may be merely protuberances, 0·5μ high, or cylindrical processes, up to 1·5μ high. These sterigmata arise anywhere along the conidiophore, but chiefly just below the septa. Some conidiophores (? the younger) bear one or two sterigmata on each segment, except the terminal one, which is naked (fig. 20). Others (? older) bear sterigmata in a ring immediately below the septa, the apex of the segment being inflated to a diameter of 3μ; and on these conidiophores the terminal segment is usually furnished with several sterigmata (fig. 19). The sterigmata in these latter conidiophores are not confined to the swollen regions immediately below the septa; on some segments all are in that position, but on others one or two sterigmata may be situated near the middle of a segment. In some instances three cylindrical sterigmata may arise close together and spread out fan-wise.

Each sterigma gives rise to a chain of conidia (fig. 21). These chains consequently arise either in whorls from the conidiophore or scattered along its length, with a group of up to at least six from the terminal segment.

The conidia are hyaline, oval, 1.5–3 × 1·2–2μ, or globose, 1·2–2μ diameter, white in mass.

Although this species has, on a first examination, the appearance of a *Gonatorrhodiella*, it differs from the type species, *Gonatorrhodiella parasitica* Thaxter, in several respects. In the latter the conidiophore bears large globose swellings, covered with minute sterigmata, and the chains of conidia arise solely from the swellings, while the terminal swelling bears a dense head of chains of conidia. In *Gonatorrhodiella parasitica* the conidiophore at first terminates in a globose head, densely covered with chains of conidia, like an *Aspergillus*. Growth then occurs from the apex of the head, with the formation of a short stalk and another globose head; and this process is continued until there is produced a long conidiophore, with globose inflations at intervals. Alternatively, two hyphae, or stalks, may arise

from a swelling. The growth of the conidiophore is consequently indefinite, and the swellings represent successive effete heads.

In the fungus on *Aleyrodes* the growth of the conidiophore is definite. It terminates in a differentiated apical segment, and does not subsequently "grow through" that segment. Moreover, the apical segment is formed before the swellings on the conidiophore. At first the conidiophore is regular, and the inflations below the septa appear to be due chiefly to the subsequent development of sterigmata in that position. These sterigmata appear to be formed in succession, not simultaneously, at each septum. Consequently it is doubtful whether this species is correctly referred to *Gonatorrhodiella*.

In culture the fungus departs still more widely from *Gonatorrhodiella*. Platings on neutral Raulin agar, from examples on *Aleyrodes*, gave almost pure cultures; but the structure of the conidiophore differed so greatly that it was at first thought that the species desired had not been obtained. A further comparison with the original fungus, however, showed that the two were really the same.

On neutral Raulin agar, pure white, pulvinate tufts, up to 5 mm. diameter, are formed, consisting of loosely radiating hyphae. The suberect conidiophores are $1{\cdot}5\mu$ diameter, hyaline, regular, septate at intervals of about 12μ, equal, or very slightly inflated below each septum. The terminal segment is not, or only slightly inflated, and tapers to a blunt apex. Chains of conidia arise from sterigmata of the same size and shape as in nature, but these sterigmata are scattered along the conidiophore, from one to three on each segment, and several on the terminal segment. The majority of the sterigmata are situated below the septa, but they occur singly in that position. Occasionally there may be two sterigmata opposite one another, on either side of the conidiophore, but the whorl of sterigmata which occurs below a septum in nature has not been observed in culture, though the cultures have been kept for two months. Hence the appearance of the conidiophores in culture is quite different from that of the majority of the conidiophores in nature; they are not evidently nodulose when examined under a medium magnification. They can, however, be matched by some of the conidiophores which occur in nature, apparently the younger conidiophores.

On maize-meal agar (tubes) the fungus spreads over the medium in a loose somewhat fleecy layer, the reverse being pale yellow. The growth on Naegeli agar is similar, but thinner. On neutral Raulin agar (tubes) an irregular pulvinate cushiony growth is produced, with a more or less abrupt margin and the reverse is pale ochraceous.

On sterilised potato and carrot, a compact, white, velvety,

pulvinate growth is formed, ultimately entirely covering the substratum. Growth on potato is more luxuriant than on carrot.

Gonatorrhodiella coccorum n.sp. White; conidiophores up to 0·2 mm. high, simple, sometimes branched near the base, sub-erect, lax, hyaline, septate, 1·5–2μ diameter; inflated to 3μ diameter immediately below each septum, terminating in an ovato-conoid or lanceolate segment, about 6μ high and 3μ diameter: conidia in chains, arising from slight protuberances, 0·5μ high, or cylindrical sterigmata, up to 1·5μ high, situated in whorls below the septa, and scattered over the terminal segment and along the conidiophore; conidia hyaline, white in mass, continuous, oval, 1·5–3 × 1·2–2μ, or globose, 1·2–2μ diameter.

CONIOTHYRIUM

Pycnidia which appear to be referable to *Coniothyrium* occur fairly frequently on scale insects attacked by *Cephalosporium Lecanii* in Ceylon. They have also been observed on *Tachardia Albizziae* which was attacked by a *Penicillium*. In general, they are accompanied by a *Cladosporium*. They are probably not parasitic on the insects.

In one collection, on *Lecanium viride* attacked by *Cephalosporium*, the pycnidia were globose, 80–120μ diameter, with a cylindrical truncate ostiolum, 8μ high. The pycnidial wall was thin, parenchymatous, composed of cells 5–8μ diameter, pale fuscous or pale blackish-brown by transmitted light. The spores were fuscous in mass, almost hyaline separately, oval, 2·5 × 1·5μ, or globose, 1·5μ diameter. When the pycnidium was placed in water the spores rapidly oozed out. No chains of spores were detected.

As it is probable that this fungus is merely a common saprophyte which may have been described from some other substratum, it is left unnamed for the present.

In *Trans. Brit. Myc. Soc.* VIII (1923), p. 209, I described a similar fungus, which was found at Hunstanton (England) on *Lepidosaphes ulmi* attacked by *Cephalosporium* (*Acrostalagmus*) *coccorum*. The pycnidia were globose, obscurely ostiolate, up to 80μ diameter, with hyaline, oval spores, 1·5–2 × 1μ, produced in chains. This was referred to *Sirosperma*, as *Sirosperma sparsum*, but on further consideration it would seem preferable that it should be referred to *Coniothyrium*. The Ceylon species would appear to differ in its truncate ostiolum.

It would appear probable that these pycnidial forms are related to the Cladosporiums which occur on scale insects.

Von Höhnel found that the type species of the genus *Coniothyrium* is superficial and astomate. For the species with ostiolate immersed pycnidia, which have hitherto been referred to that genus, he instituted a new genus, *Microsphaeropsis* (*Hedwigia*, LIX (1917), p. 267). The present species are superficial and ostiolate.

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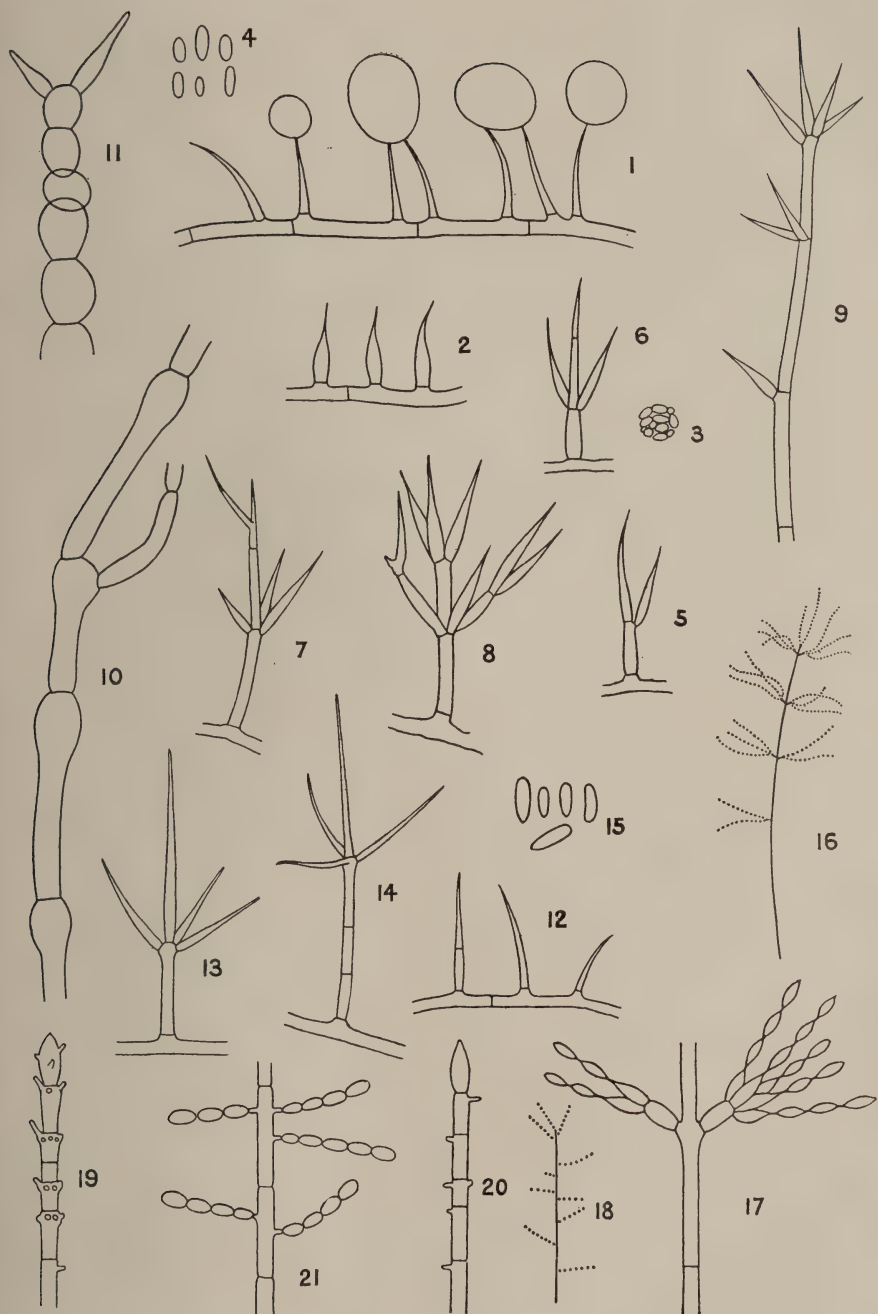
EXPLANATION OF PLATE X.

Fig. 1. Simple conidiophores of *Cephalosporium Lecanii*, heads of conidia in outline.
,, 2. Simple conidiophores of *C. Lecanii* from *Lecanium nigrum*.
,, 3. A head of conidia of *C. Lecanii*.
,, 4. Conidia of *C. Lecanii*.
Figs. 5–8. Branched conidiophores of *C. Lecanii*.
Fig. 9. Upper part of conidiophore from culture of *C. Lecanii*.
,, 10. Mycelium from culture of *C. Lecanii*.
,, 11. Abnormal mycelium and conidiophores from culture of *C. Lecanii*
,, 12. Simple conidiophores of *Cephalosporium coccorum*.
Figs. 13, 14. Branched conidiophores of *C. coccorum*.
Fig. 15. Conidia of *C. coccorum*.
,, 16. Conidiophore of *Spicaria javanica*.
,, 17. *S. javanica*, phialides and conidia.
,, 18. *Gonatorrhodiella coccorum*, conidiophore.
,, 19. *G. coccorum*, old conidiophore.
,, 20. *G. coccorum*, young conidiophore.
,, 21. *G. coccorum*, part of conidiophore from culture.

All figures × 1000, except 16 and 18, which are × 40.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STUDIES IN ENTOMOGENOUS FUNGI.

(With 1 Text-fig.)

VII. SPICARIA.

By T. Petch.

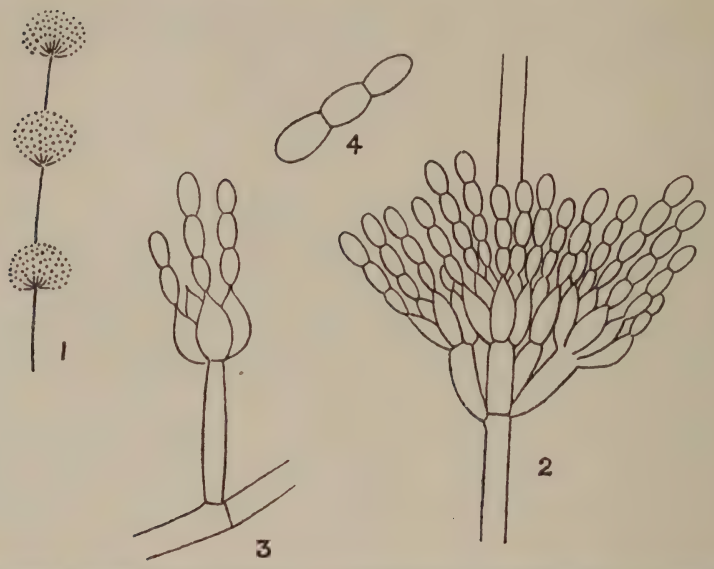
Spicaria prasina (Maubl.) Saw.

THIS species was first found in Japan by Nomura, and was sent to Maublanc, who instituted for it a new genus, *Nomuraea* (*Bull. Soc. Myc. France*, XIX, 1903, p. 295). It occurred on the larvae of *Pionea forficalis*. The genus *Nomuraea* was described as having short, erect, simple conidiophores, which bore ovoid ramuli in whorls; the conidia were ovoid, continuous, pallid, in short chains at the apices of the ramuli. The species, *Nomuraea prasina* Maubl., was described as "effusa, prasina, larvas omnino obducens; hyphis tenuibus, 2–3μ crassis; conidiis ovoideis, basi leniter attenuatis, pallide virescentibus, 4 × 2–3μ." The figure of the conidiophore shows rather close-set whorls of ramuli, while an enlarged figure of a whorl shows correctly (and contrary to the description) that the chains of conidia arise from secondary ramuli.

Sawada transferred this species to *Spicaria*, and it appears under the latter name in his *Descriptive Catalogue of Formosan Fungi* (1919).

I have specimens of this fungus on larvae of *Spodoptera mauritia* Boisd., Suduganga, Ceylon, December 23, 1919, coll. R. Senior White; on an undetermined larva on *Girardinia heterophylla* Dcne., Hakgala, Ceylon, April 11, 1924, coll. G. M. Henry; and on larvae of *Anticarsia gemmatilis* Hubn., on velvet bean, Gainesville, Florida, U.S.A., September 9, 1923, per Dr A. H. Beyer.

The affected larvae are first covered by a rather thin white felt of hyphae, from which arise suberect conidiophores, up to 150μ high, close together, forming a somewhat compact, pale-green pile. In nature the conidiophores are 1·5–2μ diameter, and bear whorls of ramuli at distances of 12 to 25μ. The ramuli and conidia form dense clusters, more or less globose, encircling the stem of the conidiophore. The appearance of the conidiophore differs from that of *Spicaria* in general, the stem being beaded at intervals with globose clusters, approximately of the same size. Several primary ramuli are situated in each whorl, completely surrounding the stem, and each bears at its apex a number of secondary ramuli (basidia). In Vuillemin's nomenclature, the fungus has phialides and prophialides. The primary ramuli (prophialides) are ovoid or cylindric, 4–6 × 2·5–3μ; the



Spicaria prasina (Maubl.) Saw. 1, conidiophore (diagrammatic); 2, whorl of phialides and conidia, ×1500; 3, a solitary branch bearing phialides, ×1500; 4, part of a chain of conidia, ×1500.

secondary ramuli (phialides) are ovoid or subcymbiform, 4 × 3μ, shortly acute at the apex. The conidia are pale green in mass, greenish hyaline individually, thick-walled, oval, 2–3 × 1·5–2μ, or globose, 1·5μ, borne in chains and united to one another over a comparatively wide area. In culture the conidia are rather larger, 3·5–4·5 × 2–2·5μ, narrow-oval, with obtuse ends, or sometimes with one end subacute; and the conidiophores are up to 3μ diameter. The conidia adhere to one another.

In some instances a cluster of secondary ramuli arises at the apex of a short lateral branch about 12μ long. Such branches arise just below the whorl of primary ramuli, and the head of conidia forms part of the cluster produced by the whorl.

Examples collected in Florida on September 9, 1923, were received in Ceylon on October 22, 1923, and cultures were immediately attempted. No germination of the conidia could be obtained on maize-meal agar, bean agar, Dox agar, Naegeli agar, or Raulin neutral agar.

Conidia from the Ceylon specimen of April 11, 1924, were sown on maize-meal agar and bean agar immediately on receipt and within a few days of collection. Growth occurred, but was very slow, nothing being visible macroscopically until five days afterwards. A month later (May 14) conidia from the insect

were plated out on maize-meal agar, but no growth resulted. Thus the conidia either lose their capacity for germination, or pass into a resting condition, comparatively early.

The cultures on maize-meal agar, begun on April 11, produced a white, thin, somewhat cottony mycelium. No conidia were evident until May 14, when a continuous, pale sea-green patch began to appear, usually at the lower margin of the colony. Transfers of conidia from one of these cultures were made on May 20; growth was evident in two days, and conidiophores appeared on May 28. In the first cultures the conidiophores formed a continuous even pile over limited areas at the margin of the colony, the remainder persisting white. In the second series the colonies had a loosely-pulvinate white centre, and a broad, flat, pale sea-green margin. On the fourth transfer extensive, uniformly flat, green colonies, with a narrow white margin, were produced.

The cultures on bean agar, begun on April 11, formed a denser, more compact, cream-coloured stroma, and spread thence in a broad, white, thin, marginal zone. Conidia were not produced until June 1, when they appeared on marginal patches similar to those of the maize-meal cultures.

Maize-meal agar is reddened by the growth of the fungus.

On 20 per cent. gelatine growth was poor. Small, thin, white patches were formed, red-brown with a white edge on the reverse. A few minute tufts of conidiophores were produced at the end of sixteen days. The gelatine was liquefied in the neighbourhood of each patch, but liquefaction did not occur throughout the tube. The gelatine was not coloured.

On Naegeli agar with cane sugar, growth was again poor. Small, white, pulvinate tufts were formed, with a somewhat radial structure. The reverse was red-brown to orange-red, but the agar was not coloured. After seven weeks the largest patch was only 1 cm. diameter, and no conidia had been produced.

On Dox agar growth was even more scanty than on the two previous media. Very minute white patches were formed, which at the end of a fortnight were not yet dense enough to show a distinct colour on the reverse. A minute green point of conidiophores was produced in the centre of the patch. The patches did not increase in size on the surface, but a quantity of submerged mycelium developed after three weeks. The reverse was ultimately white, and the agar was not coloured.

On Raulin neutral agar the development was good. The mycelium was thin at first, but extensive, and inclined to be byssoid. Conidia were produced in a week, but only on limited areas of the stroma. After six weeks the thicker parts of the stroma and the greater part of the thinner areas were still

sterile. The conidiophores were more scattered than on maize-meal agar. The reverse was deep orange-red, but the agar was not coloured.

On Raulin agar very slight growth occurred. Small floating patches were formed, the largest about 5 × 2 mm. These were flesh-coloured to purplish on the reverse. No conidia had been produced at the end of six weeks.

Growth of this species was best on maize-meal agar. On that medium the fungus develops an extensive white mycelium which bears definite, flat, continuous patches of conidiophores, usually at the margin of the culture. These patches may extend across the tube; and for a breadth of 5 mm. After repeated transfers, the whole of the colony bears conidiophores except at the extreme edge.

Spicaria Araneae Sawada.

I have specimens which I take to be this species, on a spider, Hakgala, Ceylon, May, 1912, and on a spider, Vavuniya, Ceylon, December, 1923, the latter collected by Mr G. M. Henry. The Ceylon fungus agrees with Sawada's figures, but as the only description I have seen is in Japanese, there is doubt whether the colour is the same. The specimen from Hakgala was a bright rose or purple-rose when fresh, becoming rose-purple when dry; the Vavuniya specimen was rose-purple when received.

The fungus covers the body of the spider with a continuous even pile of conidiophores, about 100μ thick, so dense that at first sight its fungal nature is not evident. The surface is minutely pulverulent. The conidiophores are more or less erect, up to 4μ diameter, and bear globose clusters of conidia at short intervals, exactly as in *Spicaria prasina*. The primary ramuli are oblong-oval or clavate, 4–5 × 2–3μ; the secondary ramuli are cylindric, narrow-oval or clavate, 4–4·5 × 2–2·5μ. The conidia are borne in chains, each chain from a very minute sterigma in the centre of the apex of a secondary ramulus; they are usually thick-walled, hyaline, oblong-oval, 4–6 × 2μ, or narrow-oval, 3–4 × 1·5–2·5μ, or globose, 2–2·5μ, and are broadly united in the chain.

On maize-meal agar inoculated with conidia, growth was slow at first, nothing being visible until the fifth day. Small white patches of mycelium were produced, which after thirteen days had become pulvinate tufts of conidiophores, pale rose-purple or purple-grey, up to 4 mm. diameter, with a narrow white margin. This pseudo-sporodochial mode of growth was very marked at first, and contrasted strongly with the diffuse growth of the conidiophores of *Spicaria javanica* and the flat patches of conidiophores in *S. prasina*. After several transfers it was

to some extent lost, as the fungus then formed a continuous white mycelium over the whole slant. The conidiophores, however, were still produced in isolated pulvinate tufts. The rose tinge becomes fainter in culture.

Maize-meal agar is not coloured by the growth of the fungus.

On 20 per cent. gelatine growth is good, but as the gelatine is completely liquefied the mycelium is at first almost entirely submerged, and conidiophores are produced only in minute tufts, unless on mycelium adherent to the sides of the tube. The latter patches, and floating patches formed later, are pale yellow, then pale purple-red, and finally purple-red, on the reverse, while the gelatine becomes reddish-brown, and at the end of about two months, blood red.

On Naegeli agar with cane sugar growth is slow. Formation of conidia did not begin until after twenty-four days in the first series of cultures, and not until the expiration of sixty-six days in the second. One tube of the latter did not produce any conidia in three months. A white, loose mycelium is formed which does not extend for more than about 2 cm. The reverse is at first pale yellow, becoming yellow-brown in two months. The agar was not coloured.

On Dox agar growth of the mycelium was better than on maize-meal or Naegeli agar, a white mycelium covering almost the whole slant. Conidia were not produced until the expiration of thirty days. The reverse is olive-brown at first, becoming yellow-brown to red-brown, and the agar is coloured yellow-brown.

On Dox and Naegeli agar the masses of conidia are bluish-purple.

On Raulin neutral agar growth is slow at first, but by the end of a month a dense woolly growth is formed, which settles down in thick, white, fleecy masses. Conidia were produced in three weeks. The reverse is pale yellow at first, becoming brownish-yellow, and finally red-brown to yellow-brown. The agar is not coloured.

In 1910 Vuillemin described a rose-coloured *Spicaria* as *Spicaria Aphodii*. It occurred on a coleopteron (*Aphodius fimetarius*) and also on vegetable debris. In a later publication (1911) he expressed a doubt whether his species was not identical with *Sporotrichum roseum* Link. I have not been able to consult Vuillemin's original paper, with the figures of *Spicaria Aphodii*, but it would appear from the description that it is not the same as *S. Araneae*.

Spicaria Aphodii, according to the description quoted by

Sartory, appeared on the body of the insect in scattered rose-coloured masses. Its mycelium was about 3μ diameter, the conidiophores being more slender and attenuated upwards. The latter bore whorls at intervals varying from 20μ below to 6μ above. The upper whorls consisted of phialides, the lower of branched ramuli, bearing groups of phialides at their apices. The phialides were flask-shaped, and consisted of a lower oval part, 4 × 2·6μ, and a neck 3–3·5μ long, 1μ diameter at the base, 0·2–0·3μ diameter at the apex. The conidia were rose-coloured, oval, 3·5–4 × 1·5–1·75μ, scarcely acute at the lower end. On the insect the conidiophores are reduced, the branches forming swollen polyhedral segments which support a continuous layer of phialides.

Spicaria javanica Bally has been described in a previous paper "*Cephalosporium* and associated fungi."* It differs from both *S. prasina* and *S. Araneae* in its morphological and cultural characters.

Spicaria Aleyrodis Johnst. was described by Johnston in 1918 from specimens on *Aleyrodes variabilis* on *Carica papaya* in Cuba. The conidiophores have whorls of short primary ramuli, each of which bears two to four flask-shaped secondary ramuli (phialides). The conidia are elliptic or oval, or more or less cylindric, hyaline, 1·6 × 3·3μ. The primary ramuli are oval. I have not seen a specimen of this. Presumably it is white. It differs from *S. javanica*, according to the description, in its flask-shaped phialides. Cultural details are not available.

In 1911 Fron described a fungus, which occurred on cocoons of *Cochylis ambiguella*, as *Spicaria verticillioides*. The chrysalis was covered with a white mould, which formed a thin coat over the body, but was thicker over the head. The phialides were flask-shaped, 5–7μ long, and the conidia 3–4 × 2–2·5μ. The conidia were said to be laxly catenulate, and in the figure they are shown as united by attenuated ends, as in *S. javanica*. Fron stated that in a young culture the phialides occurred in groups of two to four at the same level or at the apex of a hypha, so that the fungus had a verticillate arrangement; hence his choice of the specific name. His figures leave one in doubt whether they represent repent hyphae, with short lateral branches bearing phialides, or erect conidiophores with whorls of prophialides and phialides, but it would seem most probable that the former was intended.

In a later paper Fron recorded that his fungus produced *Isaria* forms in culture, and stated that it should perhaps be referred to *Isaria farinosa* Fr. He then named it "*Spicaria farinosa verticillioides* (*Isaria farinosa affinis*)." Sauvageau and

* p. 175.

Perraud had studied a fungus on *Cochylis ambiguella* in 1893, and had referred it to *Isaria farinosa*. Picard (1914) states that the fungus described by Fron is undoubtedly that of Sauvageau and Perraud, and is the species which has always been regarded by the majority of naturalists as *I. farinosa*. It is to be noted that the Tulasnes' figures of the latter species show a *Spicaria* conidiophore.

In 1916 Portier and Sartory described *Spicaria Cossus* from a specimen on larvae of *Cossus*. It formed a pinkish white covering over the insect. The hyphae were 2·5–4μ diameter, and bore more slender conidiophores which were attenuated upwards. The conidiophores bore whorls at intervals of 25μ below and 5–7μ towards the apex. The upper whorls consisted of phialides, but the lower were composed of branches which divided several times before terminating in groups of phialides. The phialides were broadly oval, attenuated above, or broadly flask-shaped, 4 × 2·6–3·5μ. The conidia were ovoid, 3–4 × 1·5–1·8μ. The fungus was said to grow well on both acid and neutral Raulin's fluid. In culture it sometimes produced coremia. The mycelium was white in culture, becoming pale cream on the development of the conidia. Except in the length of the neck of the phialides, this species would appear to resemble *S. Aphodii* on morphological characters.

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ENTOMOGENOUS FUNGI: ADDITIONS AND CORRECTIONS.

By T. Petch.

Herr H. Sydow has kindly submitted to me specimens of several species of entomogenous fungi which were described by him in 1916–17 and which were not available when my account of the genera *Hypocrella* and *Aschersonia* (*Ann. Perad.* vii (1921), pp. 167–278) was written. In some instances these necessitate an alteration of the name adopted in that paper. Descriptions of these and of other species which have recently been found are given below, together with further notes on the distribution of known species, and on some concerning which little information was available previously.

HYPOCRELLA AND ASCHERSONIA.

Hypocrella aurea Syd., *Engler's Bot. Jahrb.* liv (1916), p. 256, on leaves of an undetermined shrub, New Guinea. The stromata, according to the original description, were vivid golden. In the herbarium specimens they are reddish-yellow, pruinose, pulvinate or subglobose, contracted below, tuberculate, 1 mm. diameter, 0·7 mm. high, with a membranous hypothallus, 0·5 mm. broad. The ostiola are red-brown, conspicuous, slightly elevated. Internally the stroma is yellow towards the periphery and white in the centre. With caustic potash the yellow part becomes vivid purple-red, but the white tissue is scarcely coloured. The stroma is rather loose in texture and crumbles on cutting. The perithecia are flask-shaped, up to 0·5 mm. deep, 0·2 to 0·25 mm. diameter, with a yellow wall, 25μ thick. The asci are 8μ in diameter (9–12μ Sydow). In one ascus the part-spores were cylindric, ends square, 4–7 × 2μ; in another they were narrow-oval, with truncate ends, 8–10 × 2·5μ. Sydow's measurement of the cylindrical part-spores is 4–7 × 2μ. The fungus is parasitic on a *Lecanium*.

H. aurea resembles *H. javanica* in all respects, except that the stroma is softer. I do not think it can be maintained distinct from the latter.

Hypocrella sphaeroidea Syd., *loc. cit.*, on stems of a climbing plant, New Guinea. This is the species referred by von Höhnel to *Fleischeria sclerotioides*, and described by me as *Hypocrella olivacea* (*Ann. Perad.* vii (1921), p. 206). The latter name is antedated by Sydow's.

Hypocrella insignis Syd., *loc. cit.*, on a fallen leaf, New Guinea. The stromata are circular, almost plane, 12 mm. diameter, 0·75 mm. thick, vermilion, slightly darker in the centre, with

minute, scattered, black ostiola, more especially towards the margin. This is a flat form of *H. ceramichroa* (B. & Br.) Petch.

Hypocrella plana Syd., *op. cit.*, p. 257, on living leaves of *Piper* sp., New Guinea. The stromata in some cases are up to 4 mm. diameter, circular, almost plane, with scattered perithecial elevations, each with one perithecium, tomentose, with a thin, sometimes fimbriate margin. Other examples are oval, without a thin margin, flattened pulvinate, undulating, slightly tomentose, with scattered brown ostiola. The fungus is on an Aleyrodid. The latter specimens are exactly *H. Mollii* Koord., while the former are a frequent variation from the typical form.

Hypocrella vilis Syd., *Ann. Myc.* XV (1917), p. 215, on *Schizostachyon*, Angat, Province of Bulacan, Luzon, Philippine Is. The stromata are up to 0·8 mm. diameter, circular, flattened pulvinate, almost plane, tomentose, with a fimbriate margin, and in the herbarium specimens white or yellowish-white. Some bear waxy patches of conidia, not covering the whole of the stroma. In other cases the scale insect bears separate conidial patches, 0·2 mm. diameter, each with its own byssoid margin. The conidia are narrow-oval, continuous, 3–6 × 1·5–2μ, or globose, 2μ diameter, on conidiophores 12μ high. The perithecia are embedded in the conidial stroma, scattered or clustered, dark red-brown or yellow-brown, up to 0·12 mm. diameter. The wall, by transmitted light, is pale brownish-yellow, of obscure structure. The asci are eight-spored, with narrow-oval, one-septate, ascospores, 6–8 × 2–2·5μ; a few subglobose spores are present.

The conidial stage is *Tubercularia coccicola* Stev., and the perithecial stage is identical with *Nectria Tuberculariae* Petch (*Trans. Brit. Myc. Soc.* VII (1921), p. 157). The latter name is antedated by Sydow's, and as the combination, *Nectria vilis*, does not appear to have been employed, the species will now stand as *Nectria vilis* (Syd.) Petch.

Hypocrella libera Syd., *Ann. Myc.* XIV (1916), p. 85, on coccids on fallen leaves, Bolivia, Cobija, Rio Acre; Ule, No. 3413. The stromata are up to 10 × 6 mm., or larger by confluence, and consist of a thin basal layer, almost entirely hidden by erect processes, the whole surrounded by a white, fimbriate margin. The basal disc is up to 0·5 mm. thick, tomentose, compact but fragile, interrupted here and there, and cracking on drying. The processes are clustered, sometimes two or three confluent, ovato-conoid, constricted below, minutely tomentose, white or yellowish-white, 0·8 mm. high, 0·5–0·6 mm. diameter, apices obtuse, glabrous, amber or pale yellow-brown. The perithecia are embedded in the processes, usually one in each. The perithecial wall is hyaline and about 60μ thick, while the stromatic

tissue surrounding the perithecium is 150–250μ thick at the sides and 250μ thick at the base. This stromatic tissue is somewhat loosely attached to the wall of the perithecium, and the latter is easily dissected out. On cutting sections of the processes, the perithecium may separate from the surrounding tissue; but this tissue consists of interwoven agglutinated thick-walled hyphae, not merely loose tomentum. The outer tomentose layer consists of thick-walled hyphae, 3–4μ diameter, smooth or verrucose, flexuose or curved, about 40μ long, usually with short rectangular lumina.

The asci are up to 450μ long, 7–10μ diameter, becoming 15μ diameter when the spores are mature. The part-spores are straight or curved, oblong-oval, or cylindric and tapering slightly to the truncate or rounded ends, or sometimes with one side straight and the other curved, 8–20 × 2–2·5μ; the contents are often contracted away from the ends and divided into two parts.

In the centre of one stroma there occurred a cavity overgrown by the stroma and processes, and lined with a yellow-brown horny mass. Embedded in this mass were typical *Aschersonia* spores, narrow-fusoid, with acute tips, 10–16 × 1·5μ. Paraphyses could not be detected. The base of the cavity was not convoluted. The general appearance is that of an Aleyrodid *Aschersonia*, and it may be that the paraphyses had become disorganised.

This species is identical with *Hypocrella nectrioides* Thaxter, *Ann. Perad.* VII (1921), p. 225. The type of the latter has much smaller stromata, but is identical in other respects, and the stromata similarly sometimes have effete *Aschersonia* loculi embedded in them. The part-spores of the two species are the same, the measurement previously given for *Hypocrella nectrioides* being too small; a re-examination of the type of the latter gave the dimensions 10–20 × 2–2·5μ.

From Professor Thaxter I have received two collections of apparently the same species on a scale on *Inga edulis*, collected by J. R. Johnston at Chaguinola, Panama. In these the stromata are pale yellow, minutely pruinose, up to 1 cm. diameter, usually thin, sometimes slightly pulvinate in the centre. The central part, up to 5 mm. diameter, is opaque and compact, and merges gradually into a broad, scarious or fibrillose hypothallus. In some examples the central portion bears pycnidia, the pycnidial orifices being small, oval, yellow-brown, circularly arranged in the thinner forms, but scattered in one, more pulvinate, specimen; in one case the pycnidia are arranged in two concentric circles. At the margin of the pycnidial stromata, or scattered over the non-pycnidial examples, are erect, ovoid-

cylindric processes, white to yellowish, paler than the stroma, minutely tomentose, glabrous and subtranslucent at the apex, up to 0·5 mm. diameter and 0·3 mm. high, each containing a perithecium. The asci are chiefly immature, but some part-spores were found; these were cylindric, ends rounded, or ovoid-cylindric, ends truncate, 8–12 × 2–2·5μ.

The pycnidia in the pulvinate specimen are ovoid or sub-cylindric, up to 0·5 mm. deep, 0·25 mm. diameter. The pycnospores are fusoid, inequilateral, acute, 10–12 × 1·5–2μ, and are accompanied by paraphyses up to 80μ long.

This pycnidial stage is *Aschersonia Aleyrodis*. Consequently *Hypocrella libera* Syd. is the perithecial stage of *Aschersonia Aleyrodis*. The general structure of *Hypocrella libera* and *Aschersonia Aleyrodis* is similar to that of *Hypocrella Raciborskii* and *Aschersonia placenta*.

Sawada, in *Descriptive Catalogue of the Formosan Fungi* (Dec. 1919), records *Hypocrella Aleyrodis* (Webb.) Sawada, with the synonyms *Aschersonia Aleyrodis* Webber and *Hypocrella Raciborskii* Zimm. *Hypocrella Raciborskii*, however, is the perithecial stage of *Aschersonia placenta* B. & Br., which, in my opinion, is distinct from *A. Aleyrodis* Webber. The records of the latter for Japan appear to be erroneous, the Eastern species being *A. placenta*. Consequently, *Hypocrella Aleyrodis* (Webb.) Sawada is not the same species as *H. libera* Syd., and in any case it is antedated by *H. Raciborskii*.

Hypocrella Gaertneriana Möll. Specimens which appear to be referable to this species have been forwarded to me by Prof. Thaxter. They were collected by Rick, at Nova Petropolis, Brazil, on the stem of a bamboo. The stromata are irregularly flattened-pulvinate, up to 7 mm. diameter and 3 mm. high, and consist of several contiguous lobes arising from a rather thin, expanded base. There may be two or three equal lobes, distorted and angular along the lines of contact, or one large lobe with one or more smaller lobes at the side, or the stroma may be simple, *i.e.* reduced to one, regular, flattened-pulvinate lobe. The general appearance of the larger compound stromata gives the impression, at first sight, that they are clusters of stromata arising from several insects situated close together on the stem, each stroma based on a single insect, especially as simple stromata occur in the same collection. But examination shows that all the lobes arise from a common base, and under the base there is only one of the characteristic scars which denote the situation of the insect.

The lobes of the stroma arise from the central parts of the base, and extend outwards beyond the base, with their outer edges in contact (or nearly so) with the stem. In the simple

stromata, a stout, but short, stalk arises from the centre of the base, and the stroma in its subsequent growth extends not only upwards and horizontally, but also downwards, so that the stalk is ultimately buried in it. In some examples, a narrow horizontal groove is present between the base and the lobes of the stroma. In this latter feature the fungus recalls *Aschersonia basicystis*.

In the recent specimens the stroma is deep chocolate-brown in colour, with a grey, or pale brown, pruinose, superficial layer which rubs off. The ostiola are black, conspicuous, either slightly projecting or not. Internally the stromata are pallid or greyish, somewhat subtranslucent, except in the centre which is white and opaque. The cortical zone, in section, is brown or yellow-brown. The perithecia are rather densely crowded in a peripheral zone, and are narrow flask-shaped, up to 450μ high and 150μ diameter, with a hyaline wall. The asci are four- or eight-spored. The ascospores are 1–1·5μ in diameter, about as long as the ascus, in a parallel bundle which is only slightly twisted. They are immature in these examples, but a few have septa 9–15μ apart. Part-spores have not been observed. The stroma does not give any colour with caustic potash.

Möller described the stroma of *Hypocrella Gaertneriana* as yellow, with dark ostiola, several centimetres diameter, with close-set tubercles. His figure shows a specimen, 3·3 cm. diameter, larger and much more lobed than the recent examples. It would appear that the yellow colour fades with age. He stated that the part-spores were 4–6μ long and 1·5μ broad. I have not seen the type specimen, but only a slide from Dr Möller.

Hypocrella disjuncta Seaver. This species was very briefly described by Seaver in *Mycologia*, XII (1920), pp. 93–98. It was said by the collectors to be on "White fly" on *Bignonia unguis* L., Porto Rico, but as it is described as perched on the rather large ellipsoid scale so that the insect is distinctly visible, it would appear to have been on a *Lecanium*. The details given do not reveal any differences from *Hypocrella phyllogena* (Mont.) Speg.

Hypocrella cretacea v. Höhnel. This is recorded by Seaver (*loc. cit.*) as common in Porto Rico on *Adiantum*, chiefly in the *Aschersonia* stage. His figure shows pycnospores with attenuated tips, quite different from those of *Hypocrella cretacea*, and resembling those of *H. phyllogena*. The fungus would appear to be the flat form of the latter species.

Hypocrella hypocreoidea Petch. The *Hypocrella* stage of *Aschersonia hypocreoidea* (Cke. and Massee) Petch has been collected on a Rubiaceous plant at Kitulgala, Ceylon, March 1924. The stromata are pulvinate, up to 2 mm. diameter, or thin and flattened, up to 3·5 mm. diameter, orange-yellow, fading to

cream, tomentose, with or without a scarious hypothallus. They bear erect, ovoid processes, scattered or clustered, up to 0·4 mm. high, 0·3 mm. diameter, rounded above, orange-red at the apex, pruinose or rough with rather large, scattered masses of cells. Each process contains one perithecium. The perithecia are immature. Separate *Aschersonia* stromata occurred with the *Hypocrella*.

Aschersonia paraensis P. Henn. The specimens issued under this name in Baker, *Fungi Malayana*, No. 203, on *Psidium Guayava*, Mt Maquiling, Philippines, are *Aschersonia Coffeae* P. Henn.

Aschersonia sclerotioides P. Henn. The specimens issued under this name in Baker, *Fungi Malayana*, No. 204, on scale on *Citrus*, Mt Maquiling, Philippines, are *Aschersonia samoensis* P. Henn.

Aschersonia caespiticia Syd., Engler's *Bot. Jahrb.* LIV (1916), p. 260, on a living leaf, New Guinea, Ledermann 6856. Stromata hemispherical, 1–3 mm. diameter, pulvinate, "ochraceo-succinea"; pycnidia numerous, densely crowded, strongly projecting, ovate, up to 0·5 mm. long, 0·33 mm. broad; pycnospores acicular, ends acute, 8–10 × 1μ; basidia filiform, 15–20 × 1μ. The foregoing is taken from Sydow's description. I have not seen a specimen. Apparently this is a lecaniicolous species, resembling the *Aschersonia* stage of *Hypocrella sphaeroidea*, except in colour. In the latter respect it appears to agree with some forms of *Aschersonia marginata*, in which the pycnidia usually do not project and are either ovate or tubular.

Aschersonia duplex Berk. Specimens of this species from New Zealand on a scale on *Hedycarya arborea*, kindly forwarded by Mr G. H. Cunningham, have paraphyses up to 180μ long instead of 80μ as in the type.

Aschersonia marginata E. & E. Mr C. C. Brittlebank has kindly forwarded me specimens of this species from Australia. It occurred on *Citrus* at Townsville, Queensland. This is the first record of the species for that continent. I have also received specimens from Madagascar, *per* Mr E. E. Green, on a scale on *Citrus*, and on *Lecanium coffeae*; and from New Guinea, *per* Dr G. Bryce, on *Albizzia Lebbex* Benth.

ASCHERSONIA PAPILLATA n.sp. Stromata hard, flattened-pulvinate, sometimes depressed in the centre, up to 2·75 mm. diameter, 0·8 mm. high, subtranslucent, pallid yellow or dark honey-coloured, covered with close-set, pulvinate, subcylindric, or conoid translucent elevations, up to 0·06 mm. diameter, 0·05 mm. high, which are distinctly ostiolate when the pycnidia are mature, pruinose at first between the elevations; margin usually white, fimbriate, thinning out gradually, sometimes rounded, sometimes stout, up to 0·5 mm. broad, recurved, con-

colorous with the stroma, with a white edge; pycnidia vertically oval, 0·2–0·4 mm. high, 0·1–0·2 mm. diameter; pycnospores narrow-fusoid, 12–16 × 1–1·5μ, sometimes spuriously one-septate; paraphyses up to 150μ long. On a black Aleyrodid on *Citrus*, Hatton, Ceylon, July 7, 1922. In specimens depressed in the centre, the remains of the insect are present in the depression in the upper part of the stroma. Caustic potash colours a section of the stroma greenish-yellow to brownish-yellow, and sometimes gives a brownish-yellow extract.

PODONECTRIA.

Podonectria coccicola (Ell. & Everh.) Petch has been forwarded by Mr C. C. Brittlebank from Australia; it occurred on a scale on *Citrus*, Townsville, Queensland. This makes it probable that *Microcera rectispora* Cke. and Massee, which has previously been shown to be a *Tetracrium*, is identical with *Tetracrium coccicolum* v. H., the conidial stage of *Podonectria coccicola*.

Tetracrium coccicolum v. H. has been found on *Chionaspis Manni* on tea from Darjeeling.

BROOMELLA.

Broomella Ichnaspidis. This species was described by Zimmermann in *Centralb. f. Bakt.* Abt. II, VII (1901), p. 876. In *Trans. Brit. Myc. Soc.* VII, p. 27, the writer pointed out that from the figure and description it was not a *Broomella*. Von Höhnel, in *Ann. Myc.* XVIII, p. 75, referred it to *Oomyces*, judging from the description and figure. Zimmermann described it as having a stroma only slightly elevated above the scale insect, which bore protuberances containing perithecia. From his figure each protuberance contained a single perithecium, sharply differentiated from the stroma, and, when mature, embedded in the stroma only to about half its height. The outer layer of the perithecium wall was hyaline, the inner layers blood-red. The red colour disappeared on heating in chloral hydrate, but in the projecting part of the perithecium, the wall, and especially the ostiolum, remained brown. The general colour of the whole fungus was not given. The asci were 95–120μ long, and contained eight hyaline linear spores, almost as long as the ascus, 4–5μ broad, multiseptate, with up to 16 septa, attenuated towards one end. Zimmermann also described a var. *major*, in which the asci were up to 170μ long, with ascospores up to 155μ long and not attenuated. As previously stated, the ascospores figured resemble those of *Podonectria coccicola* (Ell. & Everh.) Petch.

Recently I received specimens of scale insect fungi on leaves of *Citrus medica* from Malang, Java, kindly sent by Dr K. Friederichs. Though the collection consisted of half-a-dozen leaves only, it included *Sphaerostilbe coccidophthora*, *Lisea Par-*

latoriae, Myriangium sp., and *Podonectria coccicola*, with its conidial stage, *Tetracrium coccicolum*.

The ascospores of the *Podonectria* were closely septate and 6–7μ broad. A few stromata, however, were different. These had the usual byssoid stroma overlying the scale, sparsely covered with thick-walled perithecia, but the thick brown outer parenchymatous layer terminated abruptly at about two-thirds the height of the perithecium, leaving the upper part conical, black and glabrous. The appearance of these perithecia is exactly that of Zimmermann's *Broomella*. The hyaline layer noted by Zimmermann is strongly reticulated and composed of large cells, as compared with the small brown cells of the thick parenchymatous wall. It appears to be external on the upper glabrous part of the perithecium, and to underlie the thick outer parenchymatous layer in the lower part. The asci of these perithecia were 150–165 × 16–18μ, accompanied by numerous linear paraphyses, and the ascospores, 140–160 × 4μ, closely septate, with septa, 5–8μ apart, elongated fusoid, with obtuse tips. No red was observable in these specimens. The perithecia were ovate, up to 0·4 mm. diameter.

In one or two other stromata, however, the broken perithecia showed a vermilion interior. But in these the perithecia were uniformly dark brown externally and thick-walled, the outer parenchymatous layer being continued over the apex of the perithecium. The red colour quickly disappeared in alcohol, leaving the cells brown. The perithecia were minute, globose, about 0·2 mm. diameter. The ascospores were 4μ broad, and multiseptate, identical with those of the previous specimens.

Judging from these specimens it would appear that Zimmermann's *Broomella* is a *Podonectria* in which the thick outer parenchymatous layer is lacking over the apex of the perithecium. But, whereas Zimmermann found such perithecia with a red inner layer, in the present case the perithecial wall of exactly similar perithecia is brown, and the red coloration occurs in perithecia which have a normal, uniformly thick wall. Consequently it would seem that neither of Zimmermann's characters is constant, and the circumstances suggest that both are abnormalities of *Podonectria coccicola*. The specimens differ from the average examples of *P. coccicola* in the close septation of the ascospores and their small breadth. *P. coccicola* has ascospores which, as a rule, vary in breadth from 7 to 9μ. But the undoubted specimens of *P. coccicola* in the present collection have ascospores just as closely septate, and only 6–7μ broad.

The final decision as to the identity of *Broomella Ichnaspidis* must await the discovery of further specimens, but it would seem quite certain that it is a *Podonectria*.

NECTRIA.

Tubercularia coccicola Stev., the conidial stage of *Nectria vilis* was found on *Lecanium hemisphericum* on tea, Yarravale, Ceylon, August 29, 1922, and on *Ceroplastes* sp., on *Santalum album*, Peradeniya, Ceylon, September 1922.

SPHAEROSTILBE.

Sphaerostilbe coccidophthora (Zimm.) Petch. In "Nectriae parasitic on Scale Insects" (*Trans. Brit. Myc. Soc.* VII (1921), p. 132), reference was made to a specimen on *Asterolecanium miliaris* on bamboo, which resembled *Sphaerostilbe coccidophthora* as regards the structure of the perithecia, but in which ascospores were found measuring 21–27 × 9–10μ. The usual dimensions of the ascospores in that species lie within the limits, 13–22 × 7–9μ. In a recent collection of *S. coccidophthora* on a *Chionaspis* on *Santalum album*, Peradeniya, September 20, 1922, the ascospores measured 13–17 × 7–9μ; but one spore in the same perithecium was 28 × 12μ. The identification of the specimen on *Asterolecanium* as *Sphaerostilbe coccidophthora* is therefore probably correct.

Sphaerostilbe aurantiicola (B. & Br.) Petch has been received from Madagascar, *per* Mr E. E. Green, on *Lepidosaphes* on *Citrus*; and from New Guinea (New Ireland), coll. Dr G. Bryce, on a scale on *Hibiscus*.

COCCIDOPHTHORA.

In *Annales Mycologici*, XI (1913), p. 263, H. and P. Sydow instituted a new genus, *Coccidophthora*, for a fungus on a scale insect on *Sasa paniculata* which had been sent from Japan by K. Hara. The fungus covered the insect with a stroma, which bore densely-clustered, globoso-conoid or irregular, black perithecia, either superficial or slightly immersed, with oblong, three-septate, brown ascospores, 8–11 × 3–4·5μ.

After describing the type species, *Coccidophthora variabilis*, the authors stated that the stroma consisted of hyaline to brownish-olive hyphae, which became darker and thicker from the base upwards. Among the black perithecia there occurred cinnabar-red perithecia without spores of any kind, and these were considered to be doubtless immature perithecia of the same fungus which would become darker later.

In the following year (*Bot. Magazine*, Tokyo, XXVIII (1914), pp. 339–51, Japanese section) Hara stated that the specimens submitted to Sydow were a mixture of two fungi, a stromatic *Nectria* parasitic on the scale insect, and black perithecia of another fungus, destitute of a stroma, parasitic on the *Nectria*. This would explain why *Coccidophthora variabilis* had red perithecia among the black ones. That the stroma of the *Nectria*

was completely blackened by the parasite is parallel to the action of *Sirosperma* and *Sirosphaera*, black pycnidial fungi, on the stromata of *Aegerita Webberi*, *Hypocrella* spp., and *Nectria diploa*. There does not seem to be any doubt as to the correctness of Hara's conclusions in this respect.

Hara named the Nectria, *Nectria variabilis*, but from his figures and description it was clearly *Nectria diploa* B. & C. He also instituted a new genus, *Philonectria*, for the superparasite, which he named *Philonectria variabilis*.

The generic characters of *Philonectria* are as follows: Parasitic on other fungi: stroma none; perithecia caespitose, globose or elliptical, carbonaceous or carinous (*sic*), membranaceous, black, ostiolum papillate. Asci cylindrico-clavate, eight-spored, paraphysate, spores elliptic or fusiform, three-septate, coloured.

The type species, *P. variabilis* had spherical or subglobose, smooth, black perithecia, 250–300μ high, 220–260μ diameter, with a papillate ostiolum; asci cylindrico-clavate or lanceolate, stipitate, 80–96 × 6–9μ; paraphyses filiform, hyaline, 1–1·5μ diameter; spores elliptic or fusiform, three-septate, not or slightly constricted, yellowish-brown, 10–13 × 4–5μ.

Sydow stated that the perithecia had very minute papillate ostiola, which were often scarcely discernible, and that the asci were very shortly stalked or subsessile. The dimensions were, perithecia, 150–360μ high, 120–200μ broad; asci, 80–100 × 6–9μ; spores 8–11 × 3–4·5μ.

The characters assigned to the genus *Philonectria* do not appear to justify the institution of a new genus.

In February 1923, specimens of a *Hypocrella* were collected at Hakgala, Ceylon, on *Microtropis Wallichiana*. These were parasitised by *Sirosperma Hypocrellae*, and on microscopic examination it was found that perithecia were present with the *Sirosperma* pycnidia. The two occur intermingled, forming a continuous layer over the *Hypocrella* on a scanty byssoid stroma, the hyphae of which extend laterally over the surface of the leaf, surrounding the *Hypocrella* stroma with a black, byssoid, circular patch. These repent hyphae are regular, 3–4μ diameter, greenish olivaceous, uniting laterally into strands. Immature perithecia or pycnidia are situated on the byssoid patch, and in one specimen, erect rigid hyphae, 1·5–2μ diameter, pale brown and closely verrucose, arise from the byssoid patch, but with no necessary relation to the developing perithecia. In a second specimen these erect hyphae are lacking.

The perithecia on the *Hypocrella* stroma are superficial, black, rugose, 75μ diameter, subglobose, ostiolate, the ostiolum not elevated; the wall is thick, parenchymatous, greenish fuscous when mounted; the asci are clavate, thick-walled, eight-spored,

36–40 × 10–12μ, with biseriate spores; paraphyses were not observed; the spores are brown, fusoid or oblong, ends obtuse, three-septate, a few not constricted, but most constricted at all the septa, or strongly constricted at the median septum only, 9–12 × 3–4μ.

This species agrees with *Philonectria variabilis* in the size of its ascospores; some of the ascospores are not constricted and match Sydow's figures, but the majority are strongly constricted. It differs in the smaller perithecia and asci. Paraphyses were not observed, but it is possible that these are evanescent.

The type specimen of *Aschersonia Tamurai* from Japan contains some old black examples, in addition to the normal orange or pale yellow stromata. On a re-examination of a slide of a black specimen, it was found that the colour is due to the presence of *Philonectria variabilis*. The perithecia vary from globoso-conoid, 125μ high, 110μ diameter, with a broad papillate ostiolum, to flattened globose, 125μ diameter, without an elevated ostiolum. They are crowded on the *Aschersonia* stroma, either superficial or embedded up to the ostiolum, or scattered over the hypothallus. A few bear two or three stout, dark brown, obtuse setae, 22–32μ high, 6μ diameter, near the apex. The majority of the perithecia are effete, but mature ascospores occur free in some. These are the same shape as those of the Ceylon specimen, but larger, 14–18 × 4–6μ. The *Aschersonia* stroma is permeated by the olivaceous hyphae of the superparasite.

The Ceylon species appears to be identical with that from Japan. Consequently, *Philonectria variabilis* is the perithecial stage of *Sirosperma Hypocrellae*. The latter occurs commonly on *Nectria diploa* B. & C. But this perithecial stage would appear to fit well in *Melanomma*, according to the interpretation of that genus which has hitherto been current. In that case it will stand as *Melanomma variabilis*.

SPHAERIOIDACEAE.

The following pycnidial fungi have been found on scale insects, apparently independent of any other fungus. It is probable that these are parasitic on the insects.

ERIOTHYRIUM COCCICOLUM n.sp. Mycelium irregular, fuscous, 2μ diameter, spreading over the scale. Pycnidia superficial, flattened convex, circular or oval, about 110μ diameter, scutate, distinctly ostiolate, cover netted, somewhat, but not markedly, radial; pycnospores minute, hyaline, oblong-oval, 1·5 × 0·75μ, or subglobose, 1μ diameter. On *Lepidosaphes* sp. on *Murraya exotica* L., Peradeniya, August 1913.

PYRENOCHAETA SPARSIBARBA n.sp. Mycelium forming a compact black stroma round or over the insect and spreading in fine strands over the leaf. Pycnidia superficial on the stroma, clustered, globose, black, 80μ diameter, not ostiolate, bearing scattered, rigid setae; wall parenchymatous, black or blackish-green; setae conical, up to 36μ high, 5μ diameter below; pycnospores hyaline, oval, 2–3 × 1–1·5μ. On *Fiorinia juniperi* Leon. on *Juniperus bermudiana* L., Peradeniya, December 1923.

MURICULARIA CALVA n.sp. Pycnidia arising from a parenchymatous stroma at the margin of, or on a thin byssoid stroma over, the scale, clustered, black, ovoid, rugose, up to 150μ high, 120μ diameter, not ostiolate; wall parenchymatous, opaque, structure obscure; pycnospores tetrahedral, triangular in plan, with rounded angles and concave sides, 2μ along each side. On *Fiorinia juniperi* on *Juniperus bermudiana* L., Peradeniya, December 1923.

The conidia agree exactly with the triangular conidium figured for *Muricularia eurotioides* Sacc., but the pycnidium is not thorny.

In *Ann. Perad.* VII (1921), pp. 246–7, a purple, imperfectly developed form of *Aschersonia placenta* was recorded from Sigiriya, Ceylon, and it was suggested that the peculiarities of the stromata were caused by a super-parasitic fungus. A re-examination of this collection has shown that some of these abnormal stromata bear pycnidia of a *Coniothyrium*.

THE MARKET FUNGI OF JAPAN.

By Shigenori Kawagoe.

THERE are many species of delicious edible fungi in Japan. Some of them are popular and very important economically throughout the whole empire, others are sold in some local markets only, and some are not handled at all by the shops.

Here I will relate about some of the most significant and interesting edible fungi sold in the Japanese markets.

Cortinellus edodes P. Henn. (*Armillaria edodes* Berk.). The Japanese name is "Matsu-dake," meaning "Pine-mushroom."

This mushroom is limited to the groves of *Pinus densiflora* Sieb. & Zucc., of which the Japanese name is "Aka-matsu," meaning "Red pine." The mycelium lives with the rootlets of this species of *Pinus*, forming mycorrhiza, and never associated with other species of *Pinus* or other trees, except, in very rare

cases, it grows with *Tsuga Sieboldii* Carr. The "matsu-dake" has a peculiar aroma and a very agreeable flavour, derived from the pine tree, with which it lives. The "matsu-dake" is esteemed as the king of the Japanese edible fungi. The growing season of the "matsu-dake" is usually from the middle of October to the beginning of November, but occasionally it grows in the rainy days of May and June; in the latter case the flavour of the mushroom is inferior and it is then esteemed merely by reason of being a rarity or out of season. "Pine-mushroom hunting" ("Matsu-dake gari") is one of the annual outings of the people living in the cities and towns of the "red-pine-grove regions," for aristocrats as well as for commoners, from ancient times to the present day. Just before the beginning of the "matsu-dake" season many local men, as agents, get the right to manage the pine groves in which the mushroom grows, by paying rent to the owners or the local forestry officials, according to whether the groves belong to private persons or are State Forests. The agent, who is called "yama-ban" (meaning mountain guard), encloses his area and divides it into several parts with rice-straw rope. The price of admission varies according to the magnitude of the area and the estimated amount of the mushroom growing in the enclosure. Many picnic parties, consisting of a single, two or more families, or members of societies, or employees of companies or factories, rush to the "matsu-dake" hills, and enter the enclosures after paying the admission fee to the agents. The parties take with them provisions consisting of rice, fish or meat, vegetables, "sho-yu" (a kind of sauce made of soya-beans, barley and malted rice), "saké" (an alcoholic drink made of rice) and others. After gathering mushrooms they cook or roast part of them with the provisions they have brought, enjoy a very pleasant lunch and take the other part of the crop to their homes. "Matsu-dake" hunting is not so easy, because young mushrooms are usually covered with leaf mould and even mature ones are apt to escape the sight by the similarity of the colour of the pileus to that of leaf mould, so the pleasure and delight in the discovery of the mushroom is the greater. Some people can find the mushroom by the scent. "Matsu-dake" hunting is one of the most remarkable customs in Japan, and it is cited very often in poetry and fine arts. The "matsu-dake" is appreciated not only by picnic parties, but it is gathered by commission merchants and distributed to green-groceries in various parts of Japan. By the advantage of quick railway service, people living away from the red-pine regions can enjoy the delicious taste of a fresh "matsu-dake." The young "matsu-dake" is cooked and canned on quite a large scale, and distributed to groceries; by this means people can

eat "matsu-dake" at any season, but, of course, the canned "matsu-dake" cannot rival the fresh one in its flavour.

Cortinellus Shiitake P. Henn. (*Collybia Shiitake* Schroet.; *Lepiota Shiitake* Tanaka).

The Japanese name is "Shii-take"; "shii" is the name of a Fagaceous tree, *Pasania cuspidata* Oerst., "take" means a mushroom. This mushroom is saprophytic on dead woods of various species of *Quercus, Pasania* and other allied Fagaceous trees. It grows spontaneously in the forests of the warmer parts of Japan, but owing to the great demand people cultivate it artificially or help its natural growth. The "shii-take" is highly esteemed when fresh, but that is limited to the districts which produce it and the fresh mushroom seldom appears in the market. Almost all the production of "shii-take" is dried, usually by air, but sometimes artificial heat is applied. When the "shii-take" is dry, a characteristic aroma and a peculiar sweetish taste are produced, which do not exist when it is fresh. The dried "shii-take" is not only delicious itself, but it imparts a specially nice flavour to soup and other foods. It is consumed quite abundantly by Japanese, but is exported in great quantities to China; the dried "shii-take" is indispensable in Chinese cooking. It is one of the leading exports and one of the most important products of Japan. In nature the "shii-take" grows on decayed parts or on quite dead trunks of Fagaceous trees, but the "shii-take" growers make special substrata for culture of the mushroom. They arrange and pile up the trunks of Fagaceous trees, mostly some species of *Quercus*, in shady and properly moist places in forests. The trunks used as the substrata are called "hoda-gi." The "shii-take" growers inoculate the trunks with either the spores or the mycelia. In the former case they pour the mixture of the smashed mature mushroom and water on the incised surface of the trunks, then they cover the inoculated trunks with wet straw mats to keep them moist. Thus the spores germinate and the mycelia penetrate into the wood of the "hoda-gi." In the case of the mycelium inoculation, they carve off the surface of the "hoda-gi" in several spots and fill the holes with the blocks cut from old wood which is impregnated with the mycelium of "shii-take," and keep it moist as in the former case; then the mycelium spreads and penetrates into the wood of the new "hoda-gi." Thus the "shii-take" growers can get crops from the same "hoda-gi's" for a considerable number of years.

Rhizopogon rubescens Tul. (*R. virescens* Karst.; *R. aestivus* Schroet.). The Japanese name is "Shoh-ro"—"shoh" means pine tree, "ro" means dew drops. This globular and subterranean fungus grows under pine trees—mostly *Pinus Thunbergii*

Parl.—in the sandy soil of a sea shore or a river bank. It is very likely that the mycelium of this fungus may live with pine roots as mycorrhiza, just like the case of *Cortinellus edodes* and *Pinus densiflora*, but the biology of this fungus is not yet investigated. The "shoh-ro" hunting on a pine-clad sandy beach is a very pleasant amusement. When the sand under the pine grove is dug out with a bamboo-rake, the curious fungus just like a miniature potato tuber is found. The "shoh-ro" is not so popular as the "matsu-dake" or the "shii-take," because the supply is not so abundant. Owing, however, to the nobility of its flavour it is much esteemed as a material for soup in a high-class dinner, just like the European truffle. Recently the canning of the "shoh-ro" has become popular, and we find the canned "shoh-ro" in some groceries of the big towns, and in the cookeries of some passenger ships on long voyages, where it is kept together with cans of the "matsu-dake" and vegetables.

Phaeodon aspratus P. Henn. (*Hydnum aspratum* Berk.). The Japanese name is "Kawa-take" or "Koh-take," meaning "leather-mushroom." This is one of the common fungi sold in the Japanese groceries. It grows naturally on the humus soil in the forest. It is never used fresh. When it is dried it emits a sweetish aroma so strong that when a single mushroom is put in a room the air becomes impregnated with its odour. The dried "koh-take" looks like a piece of brownish-black leather; so the Japanese name is derived. The "koh-take" is cooked with "shoh-yu" (soya-bean sauce), sugar, and sometimes "mirin" or "saké" (the latter two being alcoholic drinks made of rice), and used as a part of dishes in a rich dinner.

Auricularia auricula-Judae Shroet. (*Hirneola auricula-Judae* Berk.). The Japanese name is "Ki-kurage"—"ki" means tree, "kurage" means a medusa or jelly-fish. As for this cosmopolitan fungus, I think there is no necessity to explain its character and habits; it grows saprophytically on almost any kind of tree, in garden, orchard, park, street, field, forest—everywhere. People do not cultivate the "ki-kurage," but just gather the natural production. We can find the dried "ki-kurage" in any groceries. The "ki-kurage" has practically neither taste nor flavour, but when it is mixed in other foods, it gives a peculiarly agreeable tactile sense in the mastication. The amount of Japanese "ki-kurage" exported to China is greater than that consumed in Japan.

There are many other market fungi in Japan, but they are rather local, so I will cite here only a few of the most interesting ones among them.

Tricholoma bicolor P. Henn. (*T. personatum* Fr.; *Agaricus bicolor* Pers.). The Japanese name is "Murasaki-shimeji" or

simply "shimeji." This mushroom is so much esteemed that there is a proverb, "Nioi matsu-dake, aji shimeji" (meaning "in flavour, the matsu-dake is superior; but in taste, the shimeji is superior). As the supply is scarce the market price of the "shimeji" is much higher than that of the "matsu-dake." The "shimeji" is cooked fresh.

Collybia velutipes Karst. (*Agaricus velutipes* Curt.; *A. austriacus* Tratt.; *A. Aesculi* Schum.; *A. nigripes* Bull.). The Japanese name is "Yenoki-take"—"yenoki" is the name of a tree, *Celtis sinensis* Pers., on which the mushroom grows saprophytically. This stalkless mushroom is esteemed because it grows in the early spring when other kinds of edible mushrooms do not grow. People peel the cortical layer of the pileus before cooking, because it is comparatively tough.

Polyporus frondosus Fr. The Japanese name is "Mai-take," meaning "dancing mushroom," the beautiful and large fruiting body with many lamellate lobes is metaphored to dancing girls waving their hands and kimono-sleeves. The "mai-take" is cooked fresh, or preserved in salt. In the latter case it is soaked in water before cooking to remove the salt.

Lactarius Hatustake Tanaka. The Japanese name is "Hatsu-take," meaning "the forerunning mushroom," because it grows prior to other mushrooms in the early autumn.

Lactarius Akahatsu Tanaka. The Japanese name is "Aka-hatsu," being the abbreviation of "aka-hatsu-take," meaning "the reddish forerunning mushroom."

The above two species of *Lactarius* grow usually on lawns composed of a grass, *Zoysia pungens* Willd. var. *japonica* Hack. The former is dirty brownish coloured, and the latter bright reddish yellow brown. They are used fresh.

Ustilago esculenta P. Henn. I cannot omit this very interesting fungus sold in the markets of Tai-wan (Formosa). The Chinese name is "Kah-peh-sŏon," meaning "white bamboo-shoot growing on the wild rice plant" (*Zizania aquatica* L.). The "kah-peh-sŏon" is the hypertrophied sprouts of *Zizania aquatica* L. (*Z. latifolia* Turcz.), filled with the mass of the sporogenous hyphae of a smut-fungus, *Ustilago esculenta* P. Henn. It has been much esteemed by Chinese races in Formosa since olden times. *Zizania aquatica* L. is a common wild grass in Taiwan as well as in the main islands of Japan, but in Taiwan it is cultivated on road-sides or in back yards in the country for the purpose of "kah-peh-sŏon" growing. If once a *Zizania* plant is affected by *Ustilago esculenta* the mycelium of the parasite is perennial within the rhizomes of the host plant and the fungus forms its chlamydospores in the deformed buds (not in the inflorescences) every year. So people select the affected plants for culture and

throw away the healthy plants as useless. Before the maturity of the chlamydospores, the mass of hyphae is snow-white and very compact; the fungus at such a stage of development is in the best condition for eating, so it is gathered just at this stage and sold in market at a good price. The Japanese people in Taiwan are also fond of it. When the spores begin to mature many black tubercles appear gradually in the white mass, then it can no more be dealt with as a market vegetable; finally the abnormal sprout is filled with a mass of black powder. This smut fungus exists also in the main islands of Japan, but Japanese people had no experience in eating it before the possession of Taiwan. In the main islands the sprouts of *Zizania* deformed by the smut are not so large as in Taiwan. The mature chlamydospores are called "Makomo-zumi"—"makomo" is the Japanese name for *Zizania aquatica*; "zumi" or "sumi" means ink or black dye. Formerly the "makomo-zumi" was sold by druggists and was used to paint eyebrows and borders of the hair by ladies or actors and sometimes used as medicine.

Umbilicaria esculenta Mink. (*Gyrophora esculenta* Miyoshi.). The Japanese name is "Iwa-take," meaning "rock-mushroom." This is not a fungus but a gelatinous lichen. But I cannot bear to omit here this interesting fungus-ally. This lichen usually grows on rocks forming dangerous cliffs, so sometimes the "iwa-take" hunters risk their lives. In some cases the hunter gets in a basket which is hung down from the top of the cliff, and gathers the lichen growing on the rocks, then, after the collection, he is pulled up to the top or put down to the bottom of the cliff. The occurrence of the "iwa-take" is very local, mostly growing in places difficult of access, in the heart of mountains. Consequently the market price is very high and the lichen is used just as a dainty in a high-class dinner. The thallus of the "iwa-take" is flat and roundish with undulate margin, in average 3–5 inches in diameter, blackish, smooth on the upper surface and fluffy on the under surface, about the centre of which there is an umbilicus or navel, with which the thallus adheres to the substratum, the rock. Like other gelatinous lichens it becomes brittle in dry weather, and gelatinous in the wet.

The common mushroom, *Psalliota campestris* Schroet. (*Agaricus campestris* L.), so popular in Europe and America, grows wild in Japan, but it is not sold in the markets.

AN INVESTIGATION OF THE HYMENIUM OF THREE SPECIES OF STEREUM.

(With 9 Text-figs.)

By A. W. Exell, B.A.

As there are apparently no accurate descriptions or figures of the hymenial structure of some of the commonest species of *Stereum*, the present work was undertaken at the suggestion of Mr F. T. Brooks.

Sections of the fructifications of the three species examined show three layers: (1) the hymenium, on the outer surface of a resupinate fructification or on the lower surface of an imbricate one; (2) the so-called intermediate or middle layer of irregularly arranged hyphae; (3) a layer of thick-walled hyphae, the subiculum, basal when the fructifications are resupinate and forming the upper surface when they are imbricate. Sometimes these layers have no very definite boundaries.

Stereum purpureum (Pers.) Fr.

Hymenium. The hyphae forming the hymenium are arranged in a parallel manner, vertical to the surface of the fructification. Branching occurs regularly in the hymenium but no septa can be distinguished in this region. There is complete absence of paraphyses and every hypha appears to be a potential basidium though it may never develop as such.

In the formation of a basidium the tip of a hypha at the surface of the hymenium becomes swollen and eventually projects beyond the surface to a greater or less extent (up to 6μ including the sterigmata). Four sterigmata are produced, the basidia being $4–5 \times 4\mu$ and the sterigmata $2–3\mu$.

Fig. 1. *Stereum purpureum.* Section of hymenium showing basidia, colourless hyphae and a hymenial cystidium. × 500.

The hyphae forming the hymenium and particularly the young basidia, stain deeply with iron alum-haematoxylin, gentian violet, etc. A large vacuole forms in the mature basidium and after the spores have been shed an empty colourless structure, with sterigmata still visible, remains projecting from the surface of the hymenium. These empty basidia may be noticed in all stages of collapse until they no longer project. Numbers of empty colourless hyphae, which originally bore basidia, are apparent in

old fructifications but are entirely absent from young hymenia in which the first basidia are forming, so that it is unlikely that any of these colourless structures can be regarded as paraphyses (fig. 1).

The structures known as hymenial and sub-hymenial cystidia will be described later.

Intermediate layer. This consists of branched hyphae, 1–1·5μ in diameter, running quite irregularly in every direction. Here and there short lengths of larger, deeply staining hyphae 2–3μ in diameter, can be made out; but the irregular arrangement of the hyphae makes it extremely difficult to decide to what extent they form a connected system.

Subiculum. This consists of thick-walled hyphae 3μ in diameter and is a well-marked layer in this species.

Cystidia. The term cystidium has been applied to very various organs in Fungi. Thus Buller (1) says: "Cystidia, like paraphyses, are sterile elements, but they differ from these in their larger size, their peculiar form, their smaller number, and frequently in the nature of their cell walls and of their contents. They are present in some species but not in others. In some species where they occur, but not in all, they produce characteristic excretions, while in certain Coprini they have a mechanical function." Buller (2) has also adopted a topographical system of nomenclature for the cystidia found in many Agaricineae. It would seem advisable to make a clear distinction between these structures and the cystidia of genera such as *Stereum* and *Corticium*, which appear to have a very different function.

The pyriform swellings in *Stereum purpureum*, which have since been called "vesicular organs," Burt (3), and "subhymenial cystidia," Rea (4), were first described by Istvânffi (5) in an account of the conducting systems of various Hymenomycetes. Describing *Stereum purpureum* he states: "Die Leitungselemente bilden hier runde, mit einem langen Stiel versehene Zellen, die in sehr grosser Anzahl auftretend, die obere Hälfte des Fruchtkörpers oft ganz ausfüllen." His "obere Hälfte des Fruchtkörpers" is really the lower half of a normally oriented imbricate fructification.

At the surface, just behind the growing region of a fructification, where the hymenium is just forming, numbers of these vesicular bodies are to be found (fig. 2). When the hymenium grows they are left behind in the typical position just at the base of the hymenium (fig. 3). They stain deeply and are conspicuous objects 9–18 × 6–10·5μ in size. Microtome sections show that, at this stage, they are contained in cavities which are probably full of liquid, as hand-sections of fresh material show no traces of air-bubbles in this region. The vesicular bodies

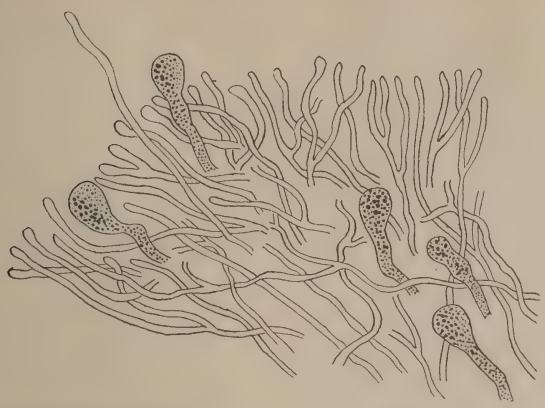

Fig. 2. *S. purpureum.* Vesicular bodies in growing region of fructification. × 500.

Fig. 3. *S. purpureum.* Section of hymenium showing vesicular bodies, one of which has collapsed. × 500

eventually lose their contents and remain as empty, colourless structures. Fixed material seemed to show that they actually burst but there is no evidence as to whether this occurs in natural conditions. As the fructification becomes older more vesicular bodies are formed in the intermediate region until there may be many layers of them. When they have become empty and disappeared, their cavities remain; so that a section of an old fructification may show numerous holes, giving the subhymenial region a perforated appearance (fig. 4).

The vesicular bodies may also occur in the hymenium and

Fig. 4. *S. purpureum.* Section of hymenium of old fructification showing the series of holes left by the collapse of the vesicular bodies. × 250.

Fig. 5. *S. purpureum.* Vesicular bodies which have budded out. × 500.

occasionally at its surface, so that the term subhymenial cystidia, while describing their usual position, is not entirely accurate.

The hyphae which produce these structures are 3–4μ in diameter, and it is found that locally at least they form a connected system. It is difficult to make out to what extent this system remains independent throughout the fructification, but the occasional deeply-staining hyphae found in the intermediate layer may form a "laticiferous" system of which the vesicular bodies are the terminations.

Occasionally the vesicular bodies may bud out to form others of similar appearance (fig. 5).

The contents of the vesicular bodies stain very deeply with iron alum-haematoxylin, Sudan III, Scharlach R, osmic acid and cotton blue. This occurs with both fresh and fixed material. After treatment with acetone, ethyl ether, or chloroform the sections still stain in the same manner so that it is unlikely that the substance which stains is a fat or oil. Very tiny droplets present in all the hyphae of the fructification stain in the same way and this makes the material unfavourable for cytological investigation.

An interesting comparison can be made with the similar swellings which occur in *Russula*. Maire (6) states that "Elles sont quelquefois, mais pas toujours, en connexion avec les laticifères quand il en existe dans la lamelle"; and later: "D'abord à peine granuleux et incolore leur contenu se charge de gouttelettes oléagineuses souvent jaunâtres, puis au début de la sporulation on voit ces gouttelettes s'émulsionner et disparaître. La cystide a alors terminé son rôle de cellule sécrétrice et elle devient excrétrice; son contenu se charge souvent de cristaux et parfois sa membrane s'incruste extérieurement." It may be mentioned that in sections of a very old specimen of *Stereum purpureum* one or two crystals were present in the subhymenial region at about the level formerly occupied by the vesicular bodies.

Burt (*loc. cit.*) has distinguished between the two species *Stereum purpureum* (Pers.) Fr. and *Stereum rugosiusculum* Berk. & Curt. mainly on the absence of *hymenial cystidia* in the former and their presence in the latter. These he describes as "slender, thin-walled, tapering hairs, not incrusted, 4–5μ in diameter, protruding up to 25μ beyond the basidia," and later, "it [*Stereum rugosiusculum*] is distinguishable from the latter [*Stereum purpureum*] only by the presence of weak flexuous hairs in the hymenium which are not visible until sectional preparations are examined with the compound microscope." He also states that he had not examined a specimen throughout its whole season of growth to determine whether the hair-like cystidia are a constant character.

Brooks (7) has pointed out that the possession of hymenial cystidia is a variable feature, that there is every stage between forms possessing many and forms devoid of them, and that the separation into two species on this character is not valid. In all the specimens examined during the present investigation, hymenial cystidia were infrequent. In many sections none were present, but three or four examples were to be found on almost any slide of a dozen or more sections, and sometimes they were as frequent as three or four to a section. They project 12–24μ from the hymenium and are 3–4μ in diameter. Burt (*loc. cit.*)

gives the dimensions 4–5μ in diameter and protruding 25μ beyond the basidia. His figure is not very clear but there seems little doubt that these are the same structures.

The typical form of a hymenial cystidium is shown in fig. 1.

Occasionally the hymenial cystidia are found to be considerably swollen at the surface level of the hymenium so as to resemble closely the vesicular bodies or subhymenial cystidia (fig. 6). As quite typical examples of the latter are frequently found in the hymenium, sometimes right at the surface and occasionally even projecting beyond (fig. 7), it appears that the so-called hymenial and sub-hymenial cystidia are one and the

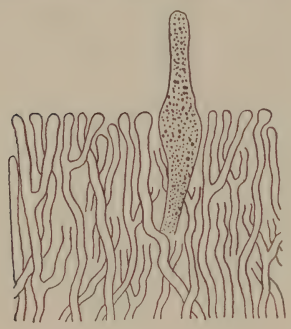

Fig. 6. *S. purpureum.* Hymenial cystidium swollen at the level of the hymenium. ×500.

Fig. 7. *S. purpureum.* Vesicular bodies, one at the surface of and one projecting from the hymenium.

same thing and that they are merely so-named according to position. If this be true, the hymenial cystidia are conducting hyphae which, failing to enlarge and form the usual vesicular bodies, have grown beyond the surface of the hymenium. They have protoplasmic contents and are not empty hairs.

Formation of successive spore deposits. It is well known that a fructification of *Stereum purpureum* may be allowed to dry up until quite hard and brittle and that, on being moistened a spore deposit is soon formed. When moist the fructification is of a consistency something like rubber. In sections stained with congo red the hyphae appear to be embedded in a transparent jelly which takes the stain very faintly. It can best be seen by examining the surface of the hymenium or the edge of the holes containing the vesicular bodies.

When pieces of fructifications which have been kept dry for several months are moistened, a spore deposit will form under favourable conditions within four to six hours. Pieces of material were fixed at intervals of an hour after moistening the

fructification. These preparations show that it is not necessary for a new hymenium to form, or for new basidia to push their way through the old hymenium. Basidia actually projecting above the surface before drying, become shrivelled; but pieces of material fixed ten minutes after moistening show tips of hyphae full of protoplasmic contents only 2–3μ from the surface. Within four hours these are able to form basidia. Thus, despite the shrivelled appearance of the fructifications in hot weather, they would presumably be producing spores in four hours after a heavy shower of rain. By successive dryings and moistenings one piece of fructification formed nine spore deposits. It is suggested that the vesicular bodies contain stores of food substances which allow of this rapid production of basidia and the formation of so many spore deposits, in rapid succession, from one hymenium. This may be a factor in the success of *Stereum purpureum* as a parasite.

Material gathered October 30, 1923, formed spore deposits up to March 12, 1924. In dried material gathered January 16, 1924, and fixed February 7, 1924, after moistening for ten minutes, the vesicular bodies were full of contents and were indistinguishable in appearance from those of fresh material.

Fructifications in Artificial Culture. Sections of rudimentary fructifications formed in artificial culture* showed a loose arrangement of basidia on the surface without any definite hymenium. There were no vesicular bodies nor cystidia of any kind.

It may be mentioned that the presence of the vesicular bodies, or, in very old material the holes left after their disappearance, is a useful means of identification of doubtful specimens.

Stereum hirsutum (Willd.) Fr.

Burt (*loc. cit.*) describes the fructification as follows: "...in structure 500–700μ thick under the hairy covering, with the intermediate layer bordered next to the hairy covering by a very dense, narrow, golden-yellow zone, the rest of the intermediate layer composed of densely and longitudinally-arranged hyphae 3–4μ in diameter, some of which in the sub-hymenium are thick-walled up to 5–6μ in diameter, and very rarely have golden-brown contents as seen between the basidia; no coloured conducting organs, cystidia nor gloeocystidia."

Microtome sections confirm this description. In stained sections the thick-walled hyphae are very conspicuous, running up into the hymenium without branching and with occasional septa. The thickness of the walls is such that the cavity of the

* I am indebted to Mr J. K. Mayo, B.A., for this material.

hypha is often very narrow. These hyphae are identical with those forming the tough, upper layer of the fructification, or dense, narrow, golden-yellow zone described by Burt, and they can sometimes be traced running from this layer, right through the intermediate layer, to the surface of the hymenium. Sometimes they project slightly beyond the surface (fig. 8). The thin-walled hyphae forming the mass of the intermediate layer are 3–4μ in diameter and frequently septate, while those of the hymenium are 1·5μ in diameter and apparently devoid of septa.

Fig. 8. *S. hirsutum.* Section of hymenium showing thick-walled hyphae. × 350.

The hymenium of *Stereum hirsutum* was described and figured by Istvánffi (*loc. cit.*), but he classes the thick-walled hyphae in the hymenium and intermediate layer as conducting organs such as those of *Stereum sanguinolentum* and does not mention the great thickness of the walls.

Marshall Ward (8) described and figured microtome sections of fructifications of *S. hirsutum* which had arisen in artificial culture. He found no thick-walled hyphae but there were two kinds of hyphae in the subhymenial region, one of which stained more deeply than the other (fig. 7, pl. 18, *loc. cit.*). This may correspond with the thick-walled system in the natural fructifications. He also mentions and figures (fig. 6, pl. 18, *loc. cit.*) pyriform swellings which occurred at the base of the fructifications. These were not recognisable in sections of natural fructifications.

Thus *S. purpureum* and *S. hirsutum* show considerable differences between fructifications formed under natural conditions and those formed in artificial culture. Some of these differences may be due to the fact that the latter are formed in a saturated atmosphere.

As in *S. purpureum*, successive spore deposits may be formed and a fructification which has been dried for months will form a spore deposit within a few hours.

Stereum sanguinolentum (A. & S.) Fr.

In a fresh state the hymenial surface of this species bleeds when wounded owing to the escape of a blood-red liquid contained in conducting hyphae. The liquid rapidly turns brown on exposure to the air.

Istvánffi gives figures of the conducting hyphae (fig. 7, pl. 4) and an accurate description of their distribution. They are slightly thick-walled, and old ones, whose contents have escaped, remain as colourless elements in the hymenium (fig. 9).

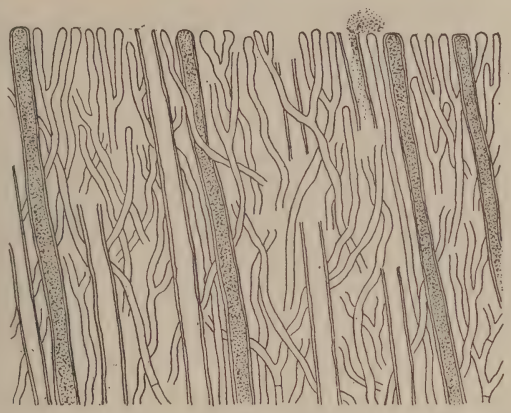

Fig. 9. *S. sanguinolentum.* Section of hymenium showing conducting organs, many of which are empty. × 500.

Artificial cultures of this species made on twigs of *Pinus sylvestris* and *Larix europaea* did not produce any fructifications though solid lumps were formed on the mycelium. Sections of these showed no basidia and no trace of conducting organs.

Method. The material was fixed in chromacetic solution and taken up to paraffin wax through cedar-wood oil. Sections were cut at 4μ and 6μ. Unless otherwise stated they were stained with iron alum-haematoxylin.

I wish to express my sincere thanks to Mr F. T. Brooks for his help and advice throughout this work.

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THE STRUCTURE AND DEVELOPMENT OF TWO NEW ZEALAND SPECIES OF SECOTIUM.

(With Plates XI and XII.)

By G. H. Cunningham,
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In the course of a revision of the Australian and New Zealand species of the genus *Secotium* (1924) the writer was somewhat doubtful as to the position this genus should occupy among the Gasteromycetes. The earlier taxonomists placed it in the tribe Podaxineae of the family Lycoperdaceae, a classification generally followed; Fischer (1900) proposed the family Secotiaceae to include it and three other genera, and more recently, Conard (1915), as a result of the study of the development of *S. agaricoides* (Czern.) Hollós, has suggested that it should be placed in the Agaricaceae. As *S. agaricoides* is a somewhat aberrant species of the genus, and as several of Conard's conclusions are at variance with ideas held by the writer, a search was made for developmental stages of two of our most common species. By thoroughly working out the development of these two species, it was hoped that some light might be shed on the taxonomic position of the genus.

Two species were chosen, one, *Secotium erythrocephalum* Tul. being typical of the genus as now defined, the other, *S. novae-zelandiae* G. H. Cunn. (*loc. cit.*, p. 11) being, in the structure of the mature plant, intermediate in position between *S. erythrocephalum* and *S. agaricoides*.

Although the following details (with minor differences) are equally applicable to either species, *S. novae-zelandiae* is discussed at greater length, as more abundant developmental stages of this species were obtained.

The genus *Secotium* is characterised by the fact that the coriaceous peridium encloses a cellular gleba, and is borne on a definite central stipe which continues through the gleba as a columella and merges with the apex of the peridium. Dehiscence is supposed to be effected by the tearing apart of the margin of the peridium from the stipe, but as this does not expose more than a very minute portion of the hymenium, and as it very frequently does not occur at all in different plants of the same species (figs. 13, 18), it would appear that the plants may be more correctly considered to be indehiscent.

Secotium novae-zelandiae (fig. 5).

MATURE PLANT.

The *peridium* is usually ovate in shape, and may attain a size of 3–5 cm. high by 1·5–3 cm. broad. It is french-grey in colour, smooth, coriaceous and slightly viscid. It is about 3 mm. thick at the apex where it merges into the columella, tapering to the base where it is lacerate and somewhat folded. The folds are commonly decurrent and pressed to the stipe. Sometimes they are held in position by remnants of the partial veil. The peridium consists of a single layer, composed of closely-compacted hyphae, whose long axes are predominantly radial.

The *gleba* is sepia-coloured and is formed of numerous anastomosing tramal plates enclosing lacunae; these are either quite large and irregular in shape, the septa being gill-like, or else definitely cellular. Specimens with a gill-like gleba approach *S. agaricoides*, and those with a cellular gleba, *S. erythrocephalum*; but the prominent stipe, smooth cortex and large elliptical spores connect it with the latter species. Extreme types of this species, as well as intermediate connecting forms, may be collected from the same substratum, where they may appear growing side by side.

A tramal plate consists of the following three layers: (*a*) the trama, consisting of a central layer of septate hyphae arranged in a parallel manner, with the long axes of the cells parallel to the surface of the plate (fig. 1, *tr.*); (*b*) the subhymenium, a layer on either side of this consisting of numerous somewhat polygonal cells (fig. 1, *sub.*); and (*c*) the hymenium, an outer palisade layer of basidia, whose long axes are at right angles to the plate (fig. 1, *hy.*). On the basidia the spores, usually four in number, are borne on long and slender sterigmata. The spores are smooth, elliptic-ovate, and sepia in colour, the colour being confined to the wall. There are no paraphyses, cystidia or other aberrant cells.

The *stipe* is up to 4 cm. long, by 4–6 mm. thick, hollow, and somewhat fibrillose on the exterior; the base is attached to the substratum (decaying wood) by numerous yellow- or violet-tinted rhizoids. The stipe continues to the apex as the *columella* —the basal portion of which is free and surrounded by a narrow conical cavity, but its upper half is attached to the tramal plates of the gleba. No trabeculae are present. Spore dispersion is dependent upon the decay of the plant, or, as this species is readily eaten by slugs, it is probable that these animals serve in some manner to disseminate them.

Both this and the following species grow upon decaying wood; *S. novae-zelandiae* is confined to lowland rain-forest, but *S. erythrocephalum* is not uncommon in gardens, especially where the soil has been at one time in forest.

Development.

General.

In all some twenty-five developmental stages of this species have been collected; of these fourteen were sufficient to give a connected idea of development.

All were fixed in picro-formol (which gave the most satisfactory results of all the solutions tried), and stained with iron-alum haematoxylin, followed by 1 per cent. iodine-green in clove oil; this combination gave excellent results, much more satisfactory than numerous others that were experimented with.

As the plants are gregarious, it is not unusual to find many developmental stages attached to the same rhizoids on one piece of decaying wood. The young plants are first noticeable as small white swellings on the upper portion of a rhizoid, often close to a more mature plant. Sections show these to consist of closely-woven undifferentiated hyphae (fig. 6), exactly resembling in shape and size those constituting the rhizoid. The young plant begins to elongate, until it is about twice as long as broad, being at this stage about 2 × 1 mm. Then a small radial indentation appears on the exterior, marking off the peridium from the stipe; this is followed by somewhat rapid growth in diameter of the peridium, which gradually increases in size until it becomes two or three times the diameter of the stipe. The peridium also assumes a definite shape, for in quarter-grown specimens it has the form of the mature plant. It continues to enlarge until about three-fourths the size of the mature plant, when the stipe begins rapidly to elongate, carrying the mature peridium upwards until it stands some 25 mm. or more above the substratum. At first the young plant is dingy-grey, but when about one-third grown, the french-grey colour begins to appear in the peridium and stipe; and in old specimens the colour changes to cyano-blue or some shade of green.

Development of the peridium and gleba.

When the plants are about 2 mm. long sections show that differentiation of the peridium and stipe has commenced. The stipe is the first to become differentiated, and at this stage consists of hyphae arranged in parallel fashion, with their long axes parallel to the long axis of the plant. Near the apex these hyphae become merged with closely and intricately-woven hyphae, the primordium of the gleba and peridium. This area becomes further differentiated, and a ring of deeply-staining tissue appears near its base. It may be seen closely appressed to and completely surrounding the columella, which at this stage is well developed at the base, although it has not become

differentiated at the apex. There is as yet no indication of the presence of the peridium, nor is any universal veil present in this or any succeeding stage. In this deeply-staining ring a small radial lacuna appears, and below it, running downwards and outwards from the inner and lower margin of the columella to the margin of the apex of the stipe, appears a wedge-shaped radial ring of loosely-woven hyphae (fig. 7). This is the first appearance of the partial veil, the development of which is discussed in detail later. This lacuna, which extends in a ring around the base of the columella, enlarges, and the hyphae lining its roof become arranged in a palisade manner. These hyphae are thinner than those of the stipe, contain abundant protoplasmic contents, and are closely compacted together. At first they are confined to the roof, but soon extend around the walls until the whole cavity, with the exception of the basal portion, or floor, is lined with them. The cavity next alters in shape, becoming laterally compressed, and extends further into the upper part of the as yet undifferentiated portion of the gleba. Into it, downward growths of the palisade layer begin to penetrate (fig. 8); these grow until they come in contact with one of the lateral walls, with which they merge, thus dividing the original cavity into several smaller ones. At the same time further lacunae begin to form in the undifferentiated portion of the gleba immediately above the original cavity. Spores now appear on a few of the first formed palisade cells (fig. 9) not as yet differentiated into regular basidia, for no definite sterigmata are present, the spores being borne singly on terminal projections. Further septa continue to grow from the roof of the original cavity and merge with its side walls, and numerous lacunae are at this stage present in the upper portion of the peridium. These continue to form until the whole of the gleba is divided into numerous cellular areas. Basidia bearing the normal number (four) of spores now appear on the first-formed tissue. The lower portion of the gleba begins to separate from the base of the columella, and this continues until a small cavity, conical in shape, is formed around the lower half of the columella. Next, the peridium becomes differentiated; at first it is quite thick, save at its margin, but it soon becomes thinner, owing to the appearance of numerous lacunae in the hyphae bordering its inner surface. From this stage until maturity, development of the gleba consists in the formation of further lacunae in the thick tramal plates (figs. 11, 12).

These lacunae appear in the following manner: cells of certain hyphae in a definite area of the tramal plate become slightly inflated, and numerous septa appear in them; this is followed by the tearing apart of these hyphae so that a small cavity is

formed (fig. 12). This increases in size and the elements of the hymenium become differentiated, so that a portion of the original plate is split into two, and is consequently thinner than before. Increase in the surface of the plates occurs, and as a result the plates are thrown into numerous folds, which may at different points come in contact with other plates and anastomose. Fusion is effected as follows: the spores are first crowded to one side as the plates approach one another, then the basidia become somewhat compressed and crushed to one side; from the subhymenium small cells grow out and merge with those of the opposite plate.

Owing to the method of the formation of these lacunae the cavities in the mature plant are very numerous, and much smaller in size than in the young plant.

From the time plants are about half grown until they reach maturity spores are being produced in ever increasing numbers; indeed, so abundant is their production that small lacunae may be filled with them, and commonly they are two or more layers deep in all the lacunae of the mature plant.

Development of the stipe and columella.

The stipe becomes differentiated immediately before the primordium of the gleba. It then continues to grow until about the time of the formation of the first cavity of the gleba, when the cavity of the stipe makes its appearance (fig. 9). The stipe then makes little growth until the plant is about one-third grown, when it increases first in thickness, and then begins to elongate rapidly until it attains full size.

The columella is discernible immediately before the appearance of the first cavity, and extends for a short distance into the as yet undifferentiated gleba. It then continues to develop slowly until the time of the appearance of the first few septa in the glebal cavity, when it is seen to have extended almost to the apex of the peridium. It does not merge with the peridium until the plant is about half grown, for the latter structure is not discernible until the glebal cavities are somewhat numerous, being represented at first only by loosely-woven hyphae.

Development of the velum partiale and mode of "dehiscence."

The first indication of a partial veil has been previously discussed. It appears immediately after the first glebal cavity and may at this stage be seen as a wedge-shaped radial area running downwards and outwards from the base of the cavity to the outer and upper portion of the stipe. It is first noticeable owing to the presence of numerous air spaces between the hyphae of this region, these hyphae being more loosely woven than those

of the primordium of the gleba. These spaces gradually increase in size, and as the peridium and stipe develop, become separated more and more, in many cases being torn apart, until at maturity a few hyphae only are present, attaching the base of the peridium to the stipe. Once the partial veil becomes differentiated it would appear that little if any further growth takes place in this region, so that the separation of the hyphae and the appearance of the large air spaces results entirely through the further growth of the stipe and peridium.

Remnants of the veil persist on the periphery of the stipe and give to it a somewhat fibrillose appearance. These remnants are accounted for when the development of the stipe is considered, for when it is about 2 mm. long the partial veil is present, attached to and surrounding it throughout its length (fig. 9). As the stipe elongates, the fibrils of the partial veil are more and more widely separated until they are torn away from the upper points of attachment, when the remnants persist on the periphery of the stipe as the fibrils alluded to.

"Dehiscence" as a rule does not proceed further than this, for one frequently obtains mature plants in which the margin of the peridium is firmly united to the stipe by these remaining fibres of the partial veil.

Development of Secotium erythrocephalum.

Early stages of this species show characters similar to those of the preceding save that the first glebal cavity appears immediately before differentiation of the columella has begun. Later stages also are similar, save that the stipe becomes more thickened and does not elongate to the same extent (fig. 16); then, too, the lacunae appear more frequently and are much smaller in size, and the tramal plates are thinner.

The peridium early becomes covered with a definite gelatinous layer, formed of hyphae which have become gelatinised (fig. 17). The colour of the peridium appears when the plants are about one-quarter grown. The first few layers of the hyphae forming the peridium, underlying the gelatinous layer, become partially filled with granules of some pigment which readily take the haematoxylin stain. They appear to be imbedded in the protoplasm lining the hyphal walls, and become more plentiful as the plant approaches maturity. This layer is absent in the preceding species.

CYTOLOGY.

Cytological details appear to be the same in both species. The hyphae of the columella, stipe and peridium are invariably binucleate, the nuclei being close together and usually side by

side. Cells of the hyphae of these tissues are from 40–60μ long × 8–10μ thick; the basidia are 15–25 × 5–8μ. The basidia at first are binucleate; the two nuclei fuse, and a somewhat larger fusion nucleus is formed; this takes up a position near the free end of the basidium, and then divides twice, the first division preceding the formation of sterigmata, the second following their appearance. After the sterigmata have begun to elongate the spores appear, and are about half size when the sterigmata have attained their full size, 8–15μ. A nucleus migrates into each spore when they are about one-quarter size, for it is not present in spores smaller than this, although invariably present in spores that are larger (fig. 2). This nucleus divides mitotically when the spore is about half size, so the mature spore is binucleate (figs. 1, 2), a character difficult to determine, as at this stage the nucleus does not readily take the stain. The nuclei are highly refractive bodies, are exceedingly small, 2–5μ, and contain one large readily-staining nucleolus. The spore eventually attains full size, and begins to colour, becoming finally sepia, the colour being confined to the epispore.

Clamp connections are abundant in the tissues of the stipe and the hyphae constituting the partial veil (fig. 3).

The writer has grown specimens of *S. novae-zelandiae* on rotting twigs buried in leaf-mould in the laboratory, and finds that development is a slow process; from the time of the beginning of differentiation until maturity covers a period of from two to three months. Where insects are excluded the plant survives for at least a month after reaching full size, then it wilts and finally deliquesces, this action being probably hastened by bacteria, as these organisms are abundant in old specimens.

CONSIDERATIONS REGARDING THE TAXONOMIC POSITION OF THE GENUS.

From a consideration of the facts set out above, it is seen that until the appearance of the first cavity the development of the two species is somewhat similar to that of *Agaricus Rodmani*, as recorded by Atkinson (1915); but from this stage onwards the development has little in common with that of *Agaricus*, or in fact with that recorded of any member of the Hymenomycetes, but approaches closely that of certain genera of the Hymenogastrineae. In particular, the repeated appearance of fresh lacunae in the undifferentiated portions of the gleba, followed later by the appearance of these spaces in the tramal plates, is in close agreement with the development of the gleba in certain genera of this family. Further, the indehiscent nature of the peridium, the cellular structure of the gleba, the basidial characters and copious spore production are

typically gasteromycetous characters. In fact, were these plants devoid of columella and stipe, they would be placed in the Hymenogastrineae without hesitation. Taking these facts into consideration the writer believes that the genus must be retained in the Gasteromycetes.

On account of the structure of the gleba, the nature of the basidia and spores, and the presence of a definite stipe and columella, the genus forms a well-defined group. The presence of the stipe and columella, together with the similarity of the early developmental stages, would tend to link it with the Agaricaceae, whereas the nature of the gleba and peridium, together with the later developmental characters, link it with certain genera of the Hymenogastraceae. It therefore occupies an intermediate position, and as no genera are known connecting it with either family it should be retained in a distinct family. The Secotiaceae of Fischer (1900) will, however, have to be emended to include only those genera possessing a stipe, columella, cellular gleba, tetrasporous sterigmatic basidia, those with a capillitium being excluded. As the structure and development of the other genera which Fischer has included in the Secotiaceae are practically unknown, no opinion can be expressed concerning them.

From a consideration of the available literature it appears to the writer that the present unsatisfactory classification of the Gasteromycetes can be attributed to: (*a*) little or no consideration having been taken of developmental characters, (*b*) genera and species having been based almost solely on morphological (macroscopic) characters, and (*c*) the microscopic structure of the basidium, spores and other characters having been completely ignored. It is hoped to investigate the development of all the genera of New Zealand Gasteromycetes with the view that ultimately sufficient information will be collected to place the classification of this sub-class on a more satisfactory basis.

The writer wishes to acknowledge the assistance of Mr J. C. Neill of this laboratory for aid in collecting and for preparing the sections of the developmental stages of both species.

SUMMARY.

1. The development of two species, *Secotium erythrocephalum* Tul. and *S. novae-zelandiae* G. H. Cunn., is dealt with.

2. Differentiation of the stipe and columella precedes the formation of the first glebal cavity in *S. novae-zelandiae*, and follows its appearance in *S. erythrocephalum*.

3. Following the appearance of the first glebal cavity, the gleba of both species becomes further differentiated through the appearance of numerous lacunae in the primordium of the gleba surrounding the columella.

4. Spores make their appearance shortly after the formation of the first few cavities, when the plant is less than one-third the normal size.

5. A definite partial veil is present, but a universal veil is wanting.

6. Early developmental stages, until the appearance of the first glebal cavity, resemble those of *Agaricus*, later stages resemble certain genera of the Hymenogastraceae.

7. Spores and hyphae are binucleate.

8. The genus should be retained in the Gasteromycetes, preferably in a distinct family, the Secotiaceae (emended).

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EXPLANATION OF PLATES XI AND XII.

[The drawings have been made with the aid of a camera lucida.]

Fig. 1. Section of a tramal plate of *Secotium erythrocephalum* Tul. *Tr.* = trama; *sub.* = subhymenium; *hy.* = hymenium. × 1000.

Fig. 2. Basidia of *S. novae-zealandiae* G. H. Cunn. × 1000. Showing various stages of nuclear division and spore formation. Fifth basidium (from left) shows the original binucleate condition, the second basidium shows these nuclei before fusion, the fourth the fusion nucleus; the sixth basidium shows four nuclei prior to migration into the spores, the first basidium shows the spores, each with a single nucleus; the third basidium bears four binucleate spores.

Fig. 3. Clamp connections from hyphae of the partial veil. × 1000.

Fig. 4. Photograph of *S. erythrocephalum*. Natural size.

Fig. 5. Photograph of *S. novae-zelandiae*. Natural size.

S. novae-zelandiae.

Fig. 6. Undifferentiated primordium. × 30.

Fig. 7. First appeaıance of the radial cavity. × 30.

Fig 8. The radial cavity has enlarged and is becoming divided into smaller areas by downgrowths from the roof of the cavity. × 25

Fig. 9. Young plant, showing greatly elongated stipe, well-defined partial veil and cavity of the stipe. × 20.

Figs. 10–12. Progressive development of the peridium and gleba. × 10.

Fig. 13. Not quite median section through a mature plant (lamellar form). × 4. Note that the base of the peridium is still attached to the stipe by remnants of the partial veil. The stipe is cut at an angle, hence the cavity is not shown in the section. Perforations in the stipe are due to insect injuries.

S. erythrocephalum.

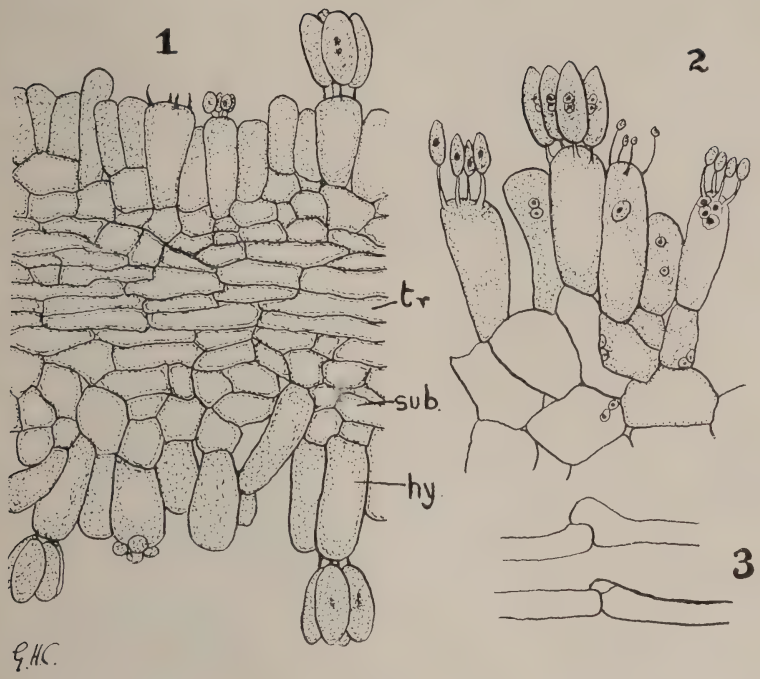
Fig. 14. Plant after first septa have been formed in the first glebal cavity. (The earlier stages are similar to the preceding, so are not shown.) × 30.

Fig. 15. Later stage in which numerous plates have appeared. Note the well-developed partial veil. × 25.

Fig. 16. Later stage showing further development of the gleba. × 15.

Fig. 17. Section showing the tremendous development of the gleba. × 8.

Fig. 18. Not quite median section through mature plant (small form). Note that the base of the peridium is attached to the stipe. The cavity of the stipe is not apparent, owing to the stipe being cut at an angle. Perforations in the stipe are due to insect injuries.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POLYPORUS ADUSTUS (WILLD.) FR. AS A WOUND PARASITE OF APPLE TREES.

By F. T. Brooks.

Polyporus adustus is of common occurrence as a saprophyte on stumps of broad-leaved trees, but the only previous record of it as a tree parasite is that by Miss E. M. Prior, who in a paper entitled "Contributions to a knowledge of 'the snap-beech' disease" (*Journal of Economic Biology*, 1913, p. 249), considered it to be the cause of this disease of beech trees.

In recent years considerable damage has been caused to apple trees in the Wisbech fruit-growing district by the entry of a fungus through wounds which were made in the process of thinning out mature trees, large wounds being especially prone to attack. *Stereum purpureum* often enters such wounds, but this is by no means the only fungus which behaves as a wound parasite in apple trees. Silvering of the foliage is not associated with the fungus now under consideration. The progress of this fungus in the tissues is marked by the death of the bark as well as the disorganisation of the wood, and one of the marked symptoms of this kind of attack is the cracking of the bark. Sometimes the growth of the fungus is stayed and then a marked fissure develops between the healthy and dead bark. Valuable fruiting branches of apple trees are often attacked and killed in this manner, but I have not yet seen an entire tree killed by this fungus, probably because in the plantation where the disease is most prevalent special care is taken to excise the fungus at an early stage. Nevertheless the cropping capacity of trees thus attacked is greatly reduced. No variety of apple grown in this district appears to be immune to this trouble, but Mr W. G. Kent informs me that the varieties most seriously affected are Newton Wonder and Lord Derby.

Protection of the wounds with Stockholm tar and with gas tar has been found utterly ineffective to prevent the entry of the fungus. Work on silver-leaf disease has shown that Stockholm tar is practically worthless as a protection against *Stereum purpureum* (Brooks and Storey, "Silver-leaf Disease IV," *Journal of Pomology*, 1923), and recent unpublished investigations on the same disease indicate that gas tar is equally ineffective in this respect. Much better results have been obtained in preventing attack by *S. purpureum* by covering wounds with thick red-oxide paint or white-lead paint, and it is likely that these substances would also keep this other wound parasite at bay.

Considerable difficulty has been experienced in determining

the identity of the fungus which is causing this new trouble. Its fructifications have never been seen in the fruit plantations. Cultures of the fungus were repeatedly obtained from diseased tissues, but until lately these gave no signs of fruit-bodies. It seemed likely that a hymenomycetous fungus was involved and this has now been demonstrated by the formation of rudimentary polyporoid fructifications in the cultures. Recently, too, large branches of diseased apple trees have been kept under laboratory conditions suitable for the development of fructifications and as these have invariably given rise to typical fruit-bodies of *Polyporus adustus*, there is no doubt that this fungus is the cause of the injury. Further investigations are proceeding.

MUSHROOMS AND TOADSTOOLS.*

By J. Ramsbottom.

In common with the other Departments of the Natural History Museum, the Botany Department, in addition to its routine of scientific investigation, is constantly consulted by the general public. Questions of all kinds are received and it has sometimes happened that the seeker after truth has taken the wrong turning; the young gentleman who wished ever so much to see the sulphuric acid plant had presumably as peculiar ideas on chemistry as he had on botany.

At this time of the year almost every post brings along boxes in all states of dilapidation containing toadstools in all stages of freshness—both positive and negative. Apart from those which are sent by people curious in these matters, the usual type of accompanying letter is: "The enclosed were found growing in my garden. Would you kindly send me the name?" A postscript is almost invariable—and reads either, "I should like to know whether they are poisonous," or, probably what is more true, "whether they are edible." It would be interesting to learn the percentage of these enquirers sufficiently trustful of the considered opinion of a mycologist to put the specimens to the test. In these matters we of this country have little faith.

Although fungi have probably been eaten since prehistoric times and classical literature has constant references to both their edible and their poisonous qualities, for most of our countrymen there are only two edible fungi—the field mushroom and the horse mushroom. Dioscorides, a physician flourishing

* Broadcast from London Station (2LO), September 21st, 1923, as one of a series of talks by members of the staff of the British Museum (Nat. Hist.).

almost 2000 years ago, divided fungi into those which were poisonous and those which were not—and it sometimes requires such a statement, somewhat embellished, to persuade rural cooks to allow one to sample one's finds. On the other hand, it is common knowledge that on the Continent many kinds of toadstools are eaten; charts giving the characters of good and bad species are to be seen in the villages of France and in the schoolrooms of Central Europe; and most of us have seen the gentlemen from Soho on their Sunday strolls through Epping Forest in search of material for their "Cèpes à la bordelaise" and "Poulard truffé". Moreover, Covent Garden, though displaying now only the field mushroom, in former days was not above harbouring Blewits, St George's Mushroom and the Parasol Mushroom, though never being anything like so catholic in its taste as are the continental markets. It might therefore not be a matter of surprise to learn that there are at least fifty kinds of toadstools of more or less common occurrence in this country which are wholesome, many of them being much more delicate in flavour than the common mushroom either wild or cultivated. In addition there are many more which are edible and many which do not attract normal people because of their small size, their appearance or their toughness. On the other hand, though the vast majority of toadstools are harmless, there are a certain small number which are poisonous.

Fungus poisoning may be grouped under various heads. Some people cannot eat fungi at all without discomfort, just as certain people must avoid strawberries, butter or honey. Again, simple indigestion may be caused by dietetic indiscretions; a heavy meal of mushrooms unaccompanied by other food, on returning from a long tramp, will probably cause regrets, as mushrooms are not very digestible. A third source of trouble is caused by eating specimens that are somewhat *passé*. Mushrooms should be eaten fresh—or left alone. Changes in composition occur in them with age just as in all other organic material. There is no more reason for purchasing putrid mushrooms than there is for acquiring mouldy meat or decaying fruit—and they are just as likely to cause inconvenience. In addition to these troubles for which fungi cannot be held directly responsible there is definite specific poisoning. This ranges from slight disorder to painful death.

Now, is there any way by which we can tell a poisonous species from an edible one? Does it peel? does its flesh change colour on breaking? does it turn a silver coin black? do animals eat it? does it grow in a wood? does it grow on highly-manured ground? does it exude milk? and many more. Every nation has similar tests and Pliny, Dioscorides and other classical authors had them.

Though hoary with antiquity all and every one is utterly worthless. There are two methods I know, and two only, for distinguishing between wholesome and unwholesome species. The first, which is probably the surer way—at least it is widest in application—is by sampling a given specimen. If nothing is heard further from the fungus it is edible: you can then decide which class it should enter—good to eat, or fit to be eaten only on the Continent. I ought to add that experiments with domestic animals are not always to be relied on so that results obtained by trying it on the dog are not absolutely conclusive. The second of the two methods is the safer, and that is to be able to identify the fungus just as one does a cow, a cabbage or any other object.

One can then find out its record and proceed accordingly. A famous Chancery judge used the opposite method and from Scotland used to write to me: "I have sampled the enclosed and find them delicious and should therefore like to know their names." Like the old lady who died through drinking tea, he did not long survive his ninety-fifth year.

Identification of the best of the edible species is a comparatively easy matter if sufficient trouble be taken to learn their characters. Anyone who can be certain of a field mushroom should have no trouble whatever in distinguishing many of the edible kinds. In the Botanical Exhibition Gallery at the Natural History Museum we have a complete series of coloured drawings of the British species of toadstools, as well as other smaller series showing a few of the more characteristic edible and poisonous forms, and of the field and cultivated mushrooms and species likely to be mistaken for them. If these (or other coloured drawings) be consulted and descriptions studied so that the points which have been found of value in distinguishing between them are thoroughly understood, there should be no more trouble in learning say fifty of these than there is in learning the cards of a pack. Though the popular idea that all toadstools are poisonous is ludicrous, indiscriminate eating of them is a pastime that should not be indulged in. Although men of experience in these matters may safely experiment, it would be the height of folly for others to enter lightheartedly on the adventure. The most poisonous fungus known is quite common all over the country and occurs in such places as Kew Gardens, Wimbledon Common and Richmond Park. This is *Amanita phalloides*. It has no popular name; but very few of the 2000 or so larger fungi have. Of more than 500 deaths from fungus poisoning recorded during the last half-century, 90 per cent. have been brought about by this fungus. In the button stage there is some very slight resemblance to the field mush-

room, but it hardly seems credible that anyone could mistake one for the other. One striking difference is that the gills always remain white and do not start pinkish and pass to dark purplish-brown. Statistics show that over half of those poisoned by this fungus die—others recover after one to three weeks of acute suffering. One disturbing fact is that the pains do not begin until at least eight hours after the meal. Intense abdominal pains, violent diarrhoea and vomiting ensue. The lurid details of the sufferings need not be entered into: in the majority of cases death occurs on the third or fourth day. To show the uselessness of the ordinary rules for spotting poisonous toadstools, *A. phalloides* peels beautifully, does not blacken a silver spoon, has a pleasant taste, and slugs grow fat on it. But doubtless sufficient has been said to suggest that trying just a little for lunch, and then if there are no ill effects having a good portion at dinner, is not so safe a way as taking much less trouble and learning the external characters once and for all.

There are one or two close relatives of *A. phalloides* which should similarly be avoided. The best known of these is the Fly Agaric, *A. muscaria*, which has a bright scarlet cap covered with white warts and appears in autumn usually in the neighbourhood of birch trees. This receives its common name from the fact that it was formerly used, broken up in milk, for killing flies. It is not so poisonous as *A. phalloides*. Moreover, its bitter and unpleasant taste and its very bright colour deter any but infants from eating it. The trouble starts almost immediately and in spite of popular tradition apparently does not cause the death of healthy people. The symptoms are mainly those of excessive intoxication and this accounts for the fact that certain Siberian tribes make use of this fungus in their religious ceremonies and orgies.

It is obvious that the few toadstools with bad reputations are pretty well known and fathers of families would be wise to leave alone all such. There seems no reason, however, to go to the length advocated by the seventeenth century botanist and poet, Sir John Salusbury:

> Let my advice perswade thy mynde
> not to truste any of that kynde
> such as be takenn for the beaste
> doe proue as poisnusse as the reste.

NOTE.

RHIZOMORPHS IN DRAIN.

(With Photograph, Plate XIII.)

In the autumn of 1923 it was reported that a drain-pipe in front of the Masonic Temple in Crown Street, Aberdeen, was blocked by material, which appeared to be plant roots. The pipe was six inches in diameter, and thirteen feet below ground. A mass of material about seven feet long was taken from the pipe, and on examination it was found to be the rhizomorphs of a fungus. The largest of these rhizomorphs reached a diameter of 1 centimetre.

It is unknown where the fungus came from. A piece of decayed wood was found near the drain, but it was destroyed before it could be examined.

The drain was laid down twenty-five years ago.

E. C. BARNETT.

REVIEW.

Researches on Fungi, Volumes II and III, by A. H. Reginald Buller. Longmans, Green & Co., pp. xii+492, 1922 and pp. xii+611, 1924. 25*s*. and 30*s*.

All who read volume I of Professor Buller's account of his fascinating researches on spore-discharge in the higher fungi have been looking forward in recent years to the appearance of other volumes of this series. Volumes II and III are now published, and those who have been expecting a renewal of the intellectual treat provided by volume I will not be disappointed. The main theme throughout these books is the same, viz. the consideration of the fructifications of the higher fungi from the standpoint of their efficiency in the production and liberation of large numbers of spores. As the author remarks in the preface to volume II, "The morphological and physiological facts which have come to light in the course of my researches have taught me that the adaptation of structure to function in the higher fungi is just as remarkable as that found in the Phanerogamia."

In volume II the author discusses first in detail the mechanism of spore discharge from the basidium, and then, having indicated that this is essentially the same in all groups of the Hymenomycetes, proceeds to describe with great elaboration the organisation of the hymenium in the *Panaeolus* sub-type of fructification in the Agaricineae, characterised by mottling of the gills and the presence of monomorphic basidia, and exemplified by *Panaeolus campanulatus, Psalliota campestris,* and other common

fungi. The way in which Professor Buller elucidates the extreme efficiency of the gills of these fungi in spore-production is a model investigation in physiological anatomy.

Volume III opens with a similarly clear interpretation of the organisation of the hymenium in other sub-types of Agaric fructification distinguished for the first time by the author. The presence of polymorphic basidia in some of these sub-types is particularly interesting. This volume also contains a full description of four of the six sub-types of the *Coprinus* form of fructification, illustrated by *C. comatus*, *C. atramentarius*, *C. lagopus* and *C. micaceus* respectively; the author brings out clearly the special features of hymenial structure in each.

The latter part of volume III deals with spore-discharge in the Rust Fungi. The author confirms the observations of Klebahn and Zalewski respectively, that sporidia and aecidiospores are violently projected into the air, and points out for the first time that the essentially curved nature of the basidium in this group is an adaptation for unimpeded spore discharge. He contrasts ingeniously the loose arrangement of the multi-septate teleutospores of *Phragmidium* with the compact aggregation of the one-septate teleutospores of *Puccinia*.

Throughout these volumes a mass of interesting information about the higher fungi is given in addition to the description of hymenial organisation. For instance, the confusion that formerly existed in regard to the basidial and oidial fructifications of *Dacryomyces deliquescens* has been cleared up, and there are interesting chapters on Bioluminescence, parasitic Agarics, Slugs as mycophagists, and so on. It seems a pity, though, that the harmony of the main theme of the remarkable efficiency of the fruit-bodies of the higher fungi should be interrupted by the inclusion of these extraneous chapters, however interesting these are in themselves. Professor Buller has such an absorbing story to tell that interest should not be diverted.

The reviewer would offer one criticism: it is that these volumes are somewhat prolix. Volume III contains 611 pages and there seems no reason why its subject matter could not have been compressed into half the space. "Of making many books there is no end," but authors should have some compassion upon their readers, especially in these days when the output of scientific literature threatens to overwhelm the investigator.

Both the present volumes are profusely and splendidly illustrated. Everyone interested in mycology will look forward with eager expectation to volume IV of these researches, which the author has promised for the near future. These volumes will be a lasting memorial to the immense zeal and success with which Professor Buller has investigated the higher fungi.

F. T. B.

PROCEEDINGS, 1924.

PHYTOPATHOLOGICAL MEETING. *28th June.*

Visit to Reading.

DINNER TO OVERSEAS MYCOLOGISTS. *4th July.*

Criterion Restaurant, London.

AUTUMN FORAY AND ANNUAL MEETING, BETTWYS-Y-COED, N. WALES. *22nd—27th September.*

AUTUMN FORAY FOR LONDON STUDENTS. *11th October.*

Visit to Virginia Water.

AUTUMN FORAY WITH ESSEX FIELD CLUB. *18th October.*

Visit to Epping Forest.

AUTUMN FORAY WITH BRITISH ECOLOGICAL SOCIETY. *25th October.*

Visit to Burnham Beeches.

MEETING, UNIVERSITY COLLEGE, LONDON. *15th November.*

Dr W. Robinson. Some Conditions controlling Growth and Reproduction in *Sporodinia.*

Mr A. W. Exell. Hymenial structure in three species of *Stereum.*

Mr W. J. Dowson. A die-back of Rambler Roses caused by *Gnomonia Rubi* Rehm.

Miss C. A. Pratt. The staling of fungal cultures.

Mr J. Ramsbottom. Fragmenta Mycologica (I).

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The Cambridge University Press has appointed the University of Chicago Press agent for the sale of *The British Mycological Society's Transactions* in the United States of America, and has authorised the following prices, viz.: $8.50 per volume; single parts $2.00 each.

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(*Recognosce notum, ignotum inspice*)

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THE BETTWS-Y-COED FORAY.

September 22nd to 27th, 1924.

THE twenty-eighth Autumn Foray and Annual General Meeting was held at Bettws-y-Coed, North Wales, from Monday, September 22nd to Saturday, September 27th, with head-quarters at the Royal Oak Hotel.

Some of the party, who had arrived for the previous week-end, had already collected a number of interesting species, which were set out in the billiard-room of the hotel. Among these were *Hypholoma catarium* and *Pleurotus geogenius*, both of which were subsequently found to be abundant on several large old sawdust heaps in the neighbourhood. Miss Eyre brought in *Hygrophorus metapodius*, and later in the week Miss Noel secured *Gyroporus cyanescens* in the immediate neighbourhood.

The exhibits were added to by Mr E. M. Day, who had brought from the neighbourhood of Minchinhampton, Gloucestershire, *Clavaria aurea* and *C. formosa*, *Collybia fumosa*, *Hygrophorus pudorinus*, *Cortinarius* (*Phlegmacium*) *turmalis*, *cyanopus*, *infractus*, *caesio-cyaneus*, *testaceus*, *C.* (*Dermocybe*) *anomalus* and *C.* (*Hydrocybe*) *subferrugineus*. Miss Wakefield showed specimens of *Boletus rubinus* W. G. Sm. collected at Kew, and Mr Sharpe, who, unfortunately, was unable to be present, sent *Xylaria polymorpha*.

The first day's hunting (Tuesday) was considerably spoilt by the weather, which was bad enough to daunt even some of those accustomed to mycological forays. The hardier spirits, however, stayed out the day, and brought in a fair number of records. The ground worked included coniferous woods at Gwydr Park, and mixed woods near Llanrwst. Among the more noteworthy finds were *Trichoglossum hirsutum*, *Hygrophorus irrigatus*, *H. nitratus*, *Cortinarius bolaris*, *C. croceoconus*, and fine specimens of *Tremellodon gelatinosum*.

In the evening, at 9 o'clock, the Annual General Meeting was held, the chief business being the election of officers and Council and consideration of locality for the 1925 Autumn Foray. Mr Cheesman was elected President for 1925, Miss Lister Vice-President, and Mr Paulson and Mr F. A. Mason members of Council. The other officers were re-elected. On the proposal of the President, Miss Gulielma Lister and Miss Annie Lorrain Smith were elected Honorary Members.

The Secretary read a letter she had received from Dr Paul A. Murphy, conveying a very warm invitation from Irish botanists to hold the Autumn Foray in Ireland in either 1925 or 1926.

After some discussion it was decided to accept the invitation and to arrange the Foray for 1925 if possible.

Mr Ramsbottom reported the purchase of the late Sir Henry Hawley's copy of Cooke's *Illustrations of British Fungi* for the library, and these and the other books already acquired were set out in the meeting-room for the use of members.

Following this Dr Wager gave a short paper on "An Aldehyde Reaction in the tissues of Fungi."

On the Wednesday, starting at noon, Bronrhedyn and Hafod Woods, on the Denbighshire side of the Conway, were visited. At the outset numerous specimens of *Xylaria carpophila* were found growing on old beech mast. A Pyrenomycete collected on a standing dead hazel stem proved to be *Cryptospora corylina*. On the whole the finds were noteworthy for quality rather than quantity. *Scleroderma Geaster, Boletus piperatus, Clavaria umbrinella, Lepiota seminuda, Tricholoma album, resplendens, saponaceum, militare, Hygrophorus laetus, miniatus, Cortinarius impennis, erythropus, spilomeus, Cordyceps ophioglossoides, C. capitata* and *C. Forquignonii* were amongst those recorded.

In the evening, at 9 o'clock, Mr Ramsbottom delivered his Presidential Address on "The Taxonomy of Fungi." Resolutions of congratulation were passed for conveyance to the French Mycological Society on the occasion of its fortieth anniversary and the School Nature Study Union on its coming of age.

On Thursday, September 25th, some mixed woods along the river between Miner's Bridge and the Swallow Falls, and beyond, were visited, while a few members of the party climbed the hill above and worked the moor land there, where *Ramsbottomia lamprosporoides* was found. Some time was spent at the outset on the large sawdust heap at Miner's Bridge, where, in addition to the two species mentioned above, were also found *Flammula sapinea, Paxillus panuoides, P. atrotomentosus, Crepidotus mollis* and several Mycetozoa, as well as some other species less characteristic of sawdust. The woods yielded *Cortinarius phoeniceus, Inocybe Godeyi, hystrix, Pluteus nanus, Clavaria Kunzei*, some very fine specimens of *Clavaria corniculata, C. fistulosa* and *C. Ardenia, Boletus rugosus* and *Otidea cochleata*.

In the evening Mr A. W. Bartlett gave his paper on "A New Species of *Urophlyctis* causing galls on *Lotus corniculatus*," and Miss Cayley described some pure cultures of certain Mycetozoa.

On Friday the woods in the opposite direction were worked, namely, at Fairy Glen and Pandy Mills. Here the species found were very much the same as on previous days. Particularly noteworthy was the abundance of *Leotia lubrica*, both the common yellowish form and a larger one with greenish head and more scaly stalk. On heathy slopes numerous specimens of

Microglossum atropurpureum were found, and *Microglossum viride* was also recorded for this day. *Nolanea pascua* was also especially abundant.

In the evening Mr Rea commented on the finds of the week. The meeting was brought to a close with the usual votes of thanks to landowners, and to Mr Whitehead of Bangor for aid in making arrangements for the Foray.

For assistance in compiling the subjoined list of species collected the Secretary is indebted to all members present, and more particularly to Mr Rea, Mr Ramsbottom, Mr Pearson, Mr Buddin, Mr E. W. Mason.

List of Species gathered during the Foray.

B. = Round Bettws; *L.* = Llanrwst; *H.* = Hafod Woods; *S.* = Swallow Falls; *F.* = Fairy Glen.

HYMENOMYCETES.

Amanita porphyria (A. & S.) Fr., *H.*, mappa (Batsch) Fr., *L.*, *H.*, muscaria (Linn.) Fr., *L.*, *H.*, *S.*, rubescens (Pers.) Fr., *L.*, *H.*, *S.* and var. annulosulphurea Gillet, *F.*

Amanitopsis vaginata (Bull.) Roze, *B.*, *L.*, fulva (Schaeff.) W. G. Sm., *H.*, *S.*, *F.*

Lepiota rhacodes (Vitt.) Fr., *L.*, granulosa (Batsch) Fr., *B.*, *L.*, *S.*, amianthina (Scop.) Fr., *B.*, *L.*, *H.*, *S.*, *F.*, seminuda (Lasch) Fr., *H.*

Armillaria mellea (Vahl) Fr., *B.*, *H.*, *S.*, *F.*

Tricholoma resplendens Fr., *L.*, *H.*, albobrunneum (Pers.) Fr., *L.*, *H.*, rutilans (Schaeff.) Fr., *L.*, *S.*, terreum (Schaeff.) Fr., *B.*, *L.*, *H.*, argyraceum (Bull.) Fr., *B.*, cuneifolium Fr., *F.*, saponaceum Fr., *B.*, *H.*, sulphureum (Bull.) Fr., *S.*, bufonium (Pers.) Fr., *S.*, album (Schaeff.) Fr., *B.*, *L.*, *H.*, *S.*, militare (Lasch) Fr., *H.*, melaleucum (Pers.) Fr., *L.*, phaeopodium (Bull.) Quél., *L.*

Russula delica Fr., *S.*, nigricans (Bull.) Fr., *H.*, *S.*, *F.*, adusta (Pers.) Fr., *L.*, *H.*, azurea Bres., *S.*, cyanoxantha (Schaeff.) Fr., *L.*, *H.*, *S.*, citrina Gillet, *S.*, furcata (Pers.) Fr., *S.*, consobrina Fr. var. sororia (Larb.) Fr., *S.*, ochroleuca (Pers.) Fr., *L.*, *H.*, *F.*, fellea Fr., *L.*, *H.*, *S.*, drimeia Cke., *B.*, fragilis (Pers.) Fr., *L.*, *H.*, *S.* and var. fallax (Schaeff.) Massee, *S.*, emetica (Schaeff.) Fr., *L.*, *S.*, atropurpurea (Krombh.) Maire, *S.*, graminicolor (Secr.) Quél., *F.*, vesca Fr., *S.*, lutea (Huds.) Fr., *S.*

Mycena pura (Pers.) Fr., *L.*, *H.*, Adonis (Bull.) Fr., *B.*, *S.*, flavo-alba Fr., *B.*, *F.*, rugosa Fr., *S.*, galericulata (Scop.) Fr., *H.*, *S.*, polygramma (Bull.) Fr., *L.*, *H.*, *S.*, *F.*, inclinata Fr., *F.*, ammoniaca Fr., *L.*, *F.*, filopes (Bull.) Fr., *H.*, Iris Berk., *S.*, vitilis Fr., *S.*, speirea Fr., *S.*, haematopus (Pers.) Fr., *H.*, sanguinolenta (A. & S.) Fr., *H.*, *S.*, galopus (Pers.) Fr., *L.*, *H.*, *S.* and var. alba Fl. Dan., *H.* and var. nigra Fl. Dan., *L.*, *H.*, epipterygia (Scop.) Fr., *L.*, *H.*, *S.*, *F.*, vulgaris (Pers.) Fr., *H.*, *S.*, rorida Fr., *L.*, *H.*

Collybia platyphylla (Pers.) Fr., *H.*, *S.*, maculata (A. & S.) Fr., *H.*, distorta Fr., *H.*, tuberosa (Bull.) Fr., *L.*, atrata Fr., *H.*

Marasmius peronatus (Bolt.) Fr., *L.*, *H.*, erythropus (Pers.) Fr., *H.*, hariolorum (DC.) Quél., *H.*, dryophilus (Bull.) Karst., *L.*, *H.*, *F.* and var. aquosus (Bull.) Rea, *H.*, *S.*, ramealis (Bull.) Fr., *L.*, *H.*

Androsaceus rotula (Scop.) Pat., *S.*, androsaceus (Linn.) Pat., *L.*, *H.*, *S.*, instititius (Fr.) Rea, *H.*

Lactarius torminosus (Schaeff.) Fr., *S.*, turpis (Weinm.) Fr., *H.*, *S.*, pubescens Fr., *L.*, *S.*, blennius Fr., *L.*, *H.*, *S.*, *F.*, pyrogalus (Bull.) Fr., *H.*, chrysorheus Fr., *H.*, piperatus (Scop.) Fr., *H.*, *S.*, vellereus Fr., *S.*, deliciosus (Linn.) Fr., *B.*, *S.*, quietus Fr., *H.*, *F.*, aurantiacus (Fl. Dan.) Fr., *H.*, *F.*, vietus Fr., *L.*, *H.*, *S.*, glyciosmus Fr., *L.*, *H.*, *S.*, *F.*, volemus Fr., *L.*, *S.*, *F.*, serifluus (DC.) Fr., *L.*, *H.*, *S.*, *F.*, mitissimus Fr., *S.*, subdulcis (Pers.) Fr., *L.*, *H.*, *S.*

Hygrophorus hypothejus Fr., *B.*, pratensis (Pers.) Fr., *B.*, *L.*, *H.*, *S.*, *F.*, virgineus (Wulf.) Fr., *B.*, *F.*, niveus (Scop.) Fr., *H.*, *S.*, metapodius Fr., *B.*, subradiatus (Schum.) Fr., var. lacmus Fr., *F.*, irrigatus (Pers.) Fr., *L.*, *F.*, laetus (Pers.) Fr., *L.*, *H.*, *F.*, ceraceus (Wulf.) Fr., *L.*, *F.* coccineus (Schaeff.) Fr., *L.*, *H.*, *S.*, *F.*, miniatus Fr., *H.*, puniceus Fr., *B.*, *H.*, *S.*, *F.*, conicus (Scop.) Fr., *H.*, *S.*, chlorophanus Fr., *H.*, *S.*, psittacinus (Schaeff.) Fr., *H.*, *F.*, nitratus (Pers.) Fr., L.

Clitocybe nebularis (Batsch) Fr., *L.*, *H.*, clavipes (Pers.) Fr., *S.*, infundibuliformis (Schaeff.) Fr., *H.*, *S.*, catinus Fr., *S.*, ditopus Fr., *S.*, inversa (Scop.) Fr., *H.*

Laccaria laccata (Scop.) B. & Br., *L.*, *H.*, *S.*, *F.* and var. amethystina (Vaill.) B. & Br., *L.*, *H.*, *S.*, *F.*

Omphalia umbellifera (Linn.) Fr., *H.*, fibula (Bull.) Fr., *H.*, gracilis Quél., *B.*

Pleurotus geogenius (DC.) Fr., *B.*, *L.*, *S.*, *F.* (on sawdust), acerosus Fr., *F.*

Cantharellus cibarius Fr., *B.*, *L.*, *H.*, *S.*, *F.*, tubaeformis Fr., *H.*, *S.*, infundibuliformis (Scop.) Fr., *H.*, *S.*, lutescens (Pers.) Fr., *L.*, *H.*, *S.*

Nyctalis parasitica (Bull.) Fr., *L.*

Lentinus cochleatus (Pers.) Fr., *L.*, *S.*, *F.*

Panus stipticus (Bull.) Fr., *L.*, *H.*, *S.*, *F.*

Lenzites betulina (Linn.) Fr., *B.*, flaccida (Bull.) Fr., ? *S.*

Pluteus cervinus (Schaeff.) Fr., *F.*, eximius Saund. & Sm. (on sawdust), *B.*, *F.*, nanus (Pers.) Fr., *S.* and var. lutescens Fr., *H.*

Entoloma sericeum (Bull.) Fr., *H.*, nidorosum Fr., *L.*, *H.*, *F.*

Nolanea pascua (Pers.) Fr., *H.*, *S.*, *F.*, papillata Bres., *L.*, *H.*

Leptonia chalybaea (Pers.) Fr., *H.*, *S.*

Paxillus involutus (Batsch) Fr., *H.*, *S.*, *F.*, panuoides Fr., *B.*, *L.*, *S.*, *F.*, atrotomentosus (Batsch) Fr., *S.* (on sawdust).

Pholiota squarrosa (Müll.) Fr., *L.*, *S.*, marginata (Batsch) Fr., *S.*, mutabilis (Schaeff.) Fr., *L.*

Inocybe pyriodora (Pers.) Fr., *S.*, rimosa (Bull.) Fr., *H.*, *S.*, geophylla (Sow.) Fr., *S.*, *F.*, Godeyi Gillet, *S.*, hystrix Fr., *S.*, cincinnata Fr., *H.*, *S.*, *F.*, fastigiata (Schaeff.) Fr., *F.*

Astrosporina asterospora (Quél.) Rea, *F.*, petiginosa (Fr.) Rea, *H.*, *S.*, proximella (Karst.) Rea, *H.*

Hebeloma mesophaeum Fr., *S.*, crustuliniforme (Bull.) Fr., var. minus Cke., *S.*, fastibile Fr., *H.*

Naucoria melinoides Fr., *L.*, *H.*, *F.*, escharoides Fr., *H.*, *F.*

Galera tenera (Schaeff.) Fr., *S.*, *F.*, hypnorum (Schrank) Fr., *L.*, *H.*, *F.*, mycenopsis Fr., *L.*

Tubaria furfuracea (Pers.) W. G. Sm., *L.*, *H.*, *S.*, *F.*

Flammula sapinea Fr., *B.*, *L.*, *S.*, *F.*, ochrochlora Fr., *S.*

Cortinarius (Phlegmacium) varius (Schaeff.) Fr., *L.*, *S.*, largus Fr., *S.*, cyanopus (Secr.) Fr., *F.*

C. (Myxacium) elatior Fr., *L.*, *H.*, *S.*, *F.*, delibutus Fr., *H.*

C. (Inoloma) alboviolaceus (Pers.) Fr., *B.*, *H.*, bolaris (Pers.) Fr., *L.*, *H.*, pholideus Fr., *H.*

C. (Dermocybe) tabularis (Bull.) Fr., *H.*, caninus Fr., *H.*, anomalus Fr., *H.*, *S.*, *F.*, lepidopus Cke., *H.*, spilomeus Fr., *H.*, phoeniceus (Bull.) Maire, *B.*, *S.*, semisanguineus (Brig.) Maire, *S.*, cinnabarinus Fr., *H.*, *S.*, cinnamomeus (Linn.) Fr., *L.*, *H.*, croceoconus Fr., *L.*

C. (Telamonia) torvus Fr., *L.*, *H.*, *S.*, impennis Fr., *H.*, hinnuleus (Sow.) Fr. *H.*, *S.*, brunneus (Pers.) Fr., *F.*, incisus (Pers.) Fr., *H.*, hemitrichus Fr., *H.*, *F.*, rigidus (Scop.) Fr., *H.*, *S.*, paleaceus (Weinm.) Fr., *H.*, *S.*, *F.*

C. (Hydrocybe) subferrugineus (Batsch) Fr., *F.*, saturninus Fr., *F.*, castaneus (Bull.) Fr., *H.*, *S.*, erythrinus Fr., *H.*, *F.*, decipiens (Pers.) Fr., *L.*, *H.*, *S.*, *F.*, germanus Fr., *F.*, obtusus Fr., *H.*, acutus (Pers.) Fr., *H.*, *S.*

Crepidotus mollis (Schaeff.) Fr., *H.*, *S.*, *F.*

Stropharia aeruginosa (Curt.) Fr., *L.*, *H.*, *S.*, albocyanea (Desm.) Fr., *L.*, *S.*, semiglobata (Batsch) Fr., *B.*

Anellaria separata (Linn.) Karst., *F.*

Hypholoma sublateritium (Schaeff.) Fr., *L.*, *H.*, *F.*, capnoides Fr., *S.*, *F.*,

epixanthum Fr., *L.*, *S.*, fasciculare (Huds.) Fr., *B.*, *H.*, *S.*, *F.*, dispersum Fr., *B.*, *S.*, lacrymabundum Fr. non Quél. *B.*, velutinum (Pers.) Fr., *S.*, appendiculatum (Bull.) Fr., *L.*, *H.*, *F.*, catarium Fr., *B.*, *L.*, *S.*, *F.*, hydrophilum (Bull.) Fr., *H.*, *S.*, *F.*, radicosum Lange (=Flammula inopus Auctt.), *S.*

Panaeolus campanulatus (Linn.) Fr., *L.*, *H.*, *F.*

Psathyra fibrillosa (Pers.) Fr., *H.*, *F.*

Psilocybe sarcocephala Fr., *S.*, uda (Pers.) Fr., var. Polytrichi Fr., *H.*, *S.*, bullacea (Bull.) Fr., *B.*, *H.*, semilanceata Fr., *L.*

Coprinus atramentarius (Bull.) Fr., *L.*, *F.*, lagopus Fr., F., plicatilis (Curt.) Fr., *F.*

Psathyrella atomata Fr., *S.*

Boletus elegans (Schum.) Fr., *L.*, *H.*, *S.*, piperatus (Bull.) Fr., *H.*, chrysenteron (Bull.) Fr., *L.*, *S.*, subtomentosus (L.) Fr., *B.*, pruinatus Fr., *H.*, edulis (Bull.) Fr., *S.*, calopus Fr., *B.*, versipellis Fr., *S.*, scaber (Bull.) Fr., *L.*, *H.*, *S.*, *F.*, rugosus Fr., *S.*, *F.*

Gyroporus cyanescens (Bull.) Rea, *F.*

Phaeoporus porphyrosporus (Fr.) Bat., *H.*

Fistulina hepatica (Huds.) Fr., *H.*

Polyporus perennis (Linn.) Fr., *L.*, *H.*, intybaceus Fr., *S.*, sulphureus (Bull., Fr., *L.*, giganteus (Pers.) Fr., *L.*, betulinus (Bull.) Fr., *L.*, *H.*, *S.*, *F.*, cuticularis (Bull.) Fr., *S.*, radiatus (Sow.) Fr., *H.*, amorphus Fr., *L.*, *F.*, adustus (Willd.) Fr., *F.*, caesius (Schrad.) Fr., *S.*, stypticus (Pers.) Fr., *L.*

Ptychogaster albus Cda, *L.*

Fomes annosus Fr., *L.*, *B.*

Polystictus versicolor (Linn.) Fr., *L.*, *H.*, *S.*, *F.*, abietinus (Dicks.) Fr., *H.*, *F.*

Poria sanguinolenta (A. & S.) Fr., *H.*, hymenocystis B. & Br., *S.*

Daedalea quercina (Linn.) Fr., *H.*

Phlebia merismoides Fr., *L.*, *S.*, radiata Fr., *S.*

Hydnum repandum (Linn.) Fr., *L.*, *H.* and var. rufescens (Pers.) Fr., *B.*, *S.*, *F.*, nigrum Fr., *S.*, ferrugineum Fr., *S.*

Irpex obliquus (Schrad.) Fr., *H.*, *S.*, *F.*

Acia uda (Fr.) Bourd. & Galz., *F.*

Odontia farinacea (Pers.) Quél., *H.*, bicolor (A. & S.) Bres., *F.*

Craterellus cornucopioides (Linn.) Fr., *L.*, *H.*, *S.*, crispus (Sow.) Fr., *L.*, *H.*, *S.*

Thelephora anthocephala (Bull.) Fr., *S.*, terrestris (Ehrh.) Fr., *S.*

Hypochnus fuscus (Pers.) Fr., *L.*, *H.*, umbrinus (Fr.) Burt, *H.*, fumosus Fr., *H.*

Stereum spadiceum Fr., *L.*, *H.*, *S.*, *F.*, rugosum (Pers.) Fr., *L.*, *H.*, *S.*, *F.*, hirsutum (Willd.) Fr., *L.*, *H.*, *S.*, *F.*

Hymenochaete rubiginosa (Dicks.) Lév., *H.*

Corticium caeruleum (Schrad.) Fr., *H.*, laeve (Pers.) Fr., *F.*, arachnoideum Berk., *H.*, atrovirens Fr., *S.*, Sambuci (Pers.) Fr., *H.*, *S.*, botryosum Bres., *L.*, confine Bourd. & Galz., *H.*, *F.*, comedens (Nees) Fr., *H.*, *S.*, praetermissum (Karst.) Bres., *H.*, *S.*

Peniophora pallidula Bres., *F.*, byssoidea (Pers.) von Hoehn. & Litsch., *L.*, sanguinea (Fr.) Bres., *L.*, velutina (DC.) Cooke, *L.*, setigera (Fr.) Bres., *L.*, *H.*, quercina (Pers.) Cooke, *H.*, *S.*

Cyphella muscigena (Pers.) Fr., *H.*

Solenia anomala (Pers.) Fr., *F.*

Clavaria cristata (Holmsk.) Fr., *L.*, *H.*, cinerea (Bull.) Fr., *L.*, *H.*, *S.*, *F.*, rugosa (Bull.) Fr., *S.*, Kunzei Fr., *S.*, corniculata (Schaeff.) Fr., *L.*, *S.*, umbrinella Sacc., *H.*, fusiformis (Sow.) Fr., *B.*, *H.*, luteo-alba Rea, *L.*, inaequalis (Müller) Fr., *H.*, *S.*, *F.*, vermicularis Fr., *H.*, fumosa (Pers.) Fr., *B.*, fistulosa (Holmsk.) Fr., *S.*, Ardenia (Sow.) Fr., *S.*

Pistillaria quisquiliaris Fr., *H.*, *S.*, *F.*

Hirneola auricula-Judae (Linn.) Berk., *S.*

Tremella mesenterica (Retz.) Fr., *H.*, *B.*, frondosa Fr., *H.*, *F.*, lutescens Pers., *L.*, *B.*, *H.*, *F.*

Exidia Thuretiana (Lév.) Fr., *H.*, *F.*, glandulosa (Bull.) Fr., *H.*, *S.*

Tremellodon gelatinosum (Scop.) Pers., *L.*, *H.*, *S.*

Dacryomyces deliquescens (Bull.) Duby, *L.*, *H.*, *S.*, *F.*

Calocera viscosa (Pers.) Fr., *L.*, *H.*, *S.*, *F.*, cornea (Batsch) Fr., *S.*, *F.*, stricta Fr., *L.*

GASTEROMYCETES.

Cynophallus caninus (Huds.) Fr., *H.*
Phallus impudicus (Linn.) Pers., *L.*, *H.*, *S.*
Lycoperdon saccatum (Vahl) Fr., *S.*, perlatum Pers., *L.*, *H.*, *F.*, pyriforme (Schaeff.) Pers., *L.*, *H.*, *S.*, *F.*
Crucibulum vulgare Tul., *F.*
Cyathus striatus (Huds.) Pers., *H.*
Scleroderma aurantium Pers., *L.*, *F.*, Geaster Fr., *H.*, *F.*, verrucosum (Vaill.) Pers., *H.*, *S.*
Sphaerobolus stellatus (Tode) Pers., *L.*, *F.*

UREDINEAE.

Uromyces Poae Rabenh., *S.*
Puccinia Violae (Schum.) DC., *S.*, Circaeae Pers., *S.*, Umbilici Guep., *F.*, Angelicae (Schum.) Fuck., *S.*, Centaureae Mart., *S.*, Hieracii (Schum.) Mart., *H.*, Chondrillae Corda, *S.*, variabilis Grev., annularis (Str.) Schlecht., *L.*, Menthae Pers., *S.*, obscura Schroet., oblongata (Link) Wint., graminis Pers. *on Oats*, *S.*, *F.*, Poarum Neils., *S.*
Gymnosporangium Juniperi Link, *S.*
Triphragmium Ulmariae (Schum.) Link, *S.*, *F.*
Phragmidium Fragariae (DC.) Wint., *S.*, violaceum (Schultz) Wint., *S.*, *F.*, Rubi (Pers.) Wint., *H.*
Coleosporium Tussilaginis (Pers.) Kleb., *S.*, *F.*, Melampyri Karst.
Pucciniastrum Epilobii (Pers.) Otth., *S.*
Thecopsora Vacciniorum (Link) Karst., *H.*, *S.*
Hyalopsora Polypodii (Pers.) Magn., *H.*
Melampsora Hypericorum (DC.) Schroet., *S.*
Melampsoridium betulinum (Pers.) Kleb., *H.*, *S.*, *F.*
Milesina Blechni Syd., *S.*

USTILAGINEAE.

Ustilago Hordei Jensen, *F.*
Entyloma microsporum Schroet., on *Ranunculus repens*, *F.*

PYRENOMYCETES.

Erysiphe Cichoracearum DC., on *Centaurea nigra*, *F.*, graminis DC., *S.*
Microsphaera Alni (DC.) Wint.
Podosphaera oxyacanthae (DC.) de By., on *Vaccinium Myrtillus*, *H.*
Phyllactinia Corylea (DC.) Karst.
Nectria cinnabarina (Tode) Fr., *F.*
Cordyceps militaris (Linn.) Link, *S.*, *F.*, ophioglossoides (Ehrh.) Link, *H.*, *F.*, capitata (Holmsk.) Link, *H.*, Forquignonii Quél., *H.*
Claviceps microcephala (Wallr.) Wint., *S.*
Chaetosphaeria phaeostroma (Dur. & Mont.) Fuck., *L.*
Stigmatea Robertiani Fr., *H.*, *F.*
Mycosphaerella maculiformis (Pers.) Schroet., *F.*, Rumicis (Desm.), *F.*
Diaporthe leiphaemia (Fr.) Sacc., *H.*, rostellata (Fr.) Nits., *F.*
Eutypa lata (Pers.) Tul., *H.*
Valsa ceratophora Tul., *F.*
Cryptospora corylina (Tul.) Fuck., *H.*
Melanconis stilbostoma (Fr.) Tul., *H.*
Diatrypella quercina (Pers.) Nits., *H.*, verrucaeformis (Ehrh.) Nits., *H.*
Diatrype disciformis (Hoffm.) Fr., *H.*
Hypoxylon fuscum (Pers.) Fr., *L.*, coccineum Bull., *L.*
Xylaria Hypoxylon (Linn.) Grev., *L.*, *H.*, *S.*, *F.*, carpophila (Pers.) Fr., *H.*, polymorpha (Pers.) Grev., *F.*
Phyllachora graminis (Pers.) Fuck., *F.*

HYSTERIALES.

Dichaena quercina Fr., *H.*
Rhopographus Pteridis (Sow.) Wint., *H.*, *S.*

TUBERALES.

Elaphomyces granulatus Fr., *H.*, *F.*

MYRIANGIALES.

Myriangium Duriaei Mont. & Berk., *H.*

DISCOMYCETES.

Helvella crispa (Scop.) Fr., *H.*, lacunosa Afz., *S.*
Leptopodia elastica (Bull.) Boud., *H.*, *F.*, *S.*
Macropodia macropus (Pers.) Fuck., *H.*
Galactinia badia (Pers.) Boud., *L.*, saniosa (Schrad.) Sacc., *H.*
Otidea onotica (Pers.) Fuck., *H.*, *S.*, *F.*, cochleata (Linn.) Fuck., *S.*
Peziza aurantia Pers., *S.*, *F.*, luteo-nitens, B. & Br., *F.*, *L.*
Lachnea hemisphaerica (Wigg.) Gill., *S.*
Ciliaria scutellata (Linn.) Quél., *H.*, *S.*, *F.*, trechispora (B. & Br.) Boud., *L.*
Cheilymenia coprinaria (Cooke) Boud., *S.*
Ramsbottomia lamprosporoides Buckley, *S.*
Ascobolus denudatus Fr. (on sawdust), *F.*
Trichoglossum hirsutum (Pers.) Boud., *B.*
Microglossum atropurpureum (Batsch) Karst., *S.*, *F.*, viride (Pers.) Gill., *F.*
Leotia lubrica (Scop.) Pers., *L.*, *H.*, *S.*, *F.*
Cudoniella acicularis (Bull.) Schroet., *L.*, *H* , *S.*
Pachydisca Laburni (B. & Br.) Boud., on Birch, *H.*
Calycella citrina (Hedw.) Quél., *H.*, *S.*, *F.*
Coryne sarcoides (Jacq.) Tul., *L.*, *H.*, *S.*, *F.*
Bulgaria inquinans (Pers.) Fr., *L.*, *H.*, *S.*, *F.*
Orbilia xanthostigma Fr., *H.*, *S.*, *F.*
Hyalinia inflatula (Karst.) Boud., *H.*
Sclerotinia Curreyana (Berk.) Karst., *S.*, *F.*
Phialea firma (Pers.) Gill., *L.*, *H.*, *S.*, *F.*
Chlorosplenium aeruginosum (Oeder.) de Not., *H.*, *S.*, *F.*
Helotium fructigenum (Bull.) Fuck., *L.*, *H.*, *S.*, *F.*, virgultorum (Wahl.) Karst., *H.*, herbarum (Pers.) Fr., *F.*, epiphyllum (Pers.) Fr., *H.*
Dasycypha virginea (Batsch) Fuck., *H.*, *S.*
Trichopeziza caesia (Pers.) Boud., *H.*, *F.*
Mollisia cinerea (Batsch) Karst., *H.*, *S.*, *F.*
Phacidium multivalve (DC.) Kunze, *H.*
Pezicula eucrita Karst., *H.*
Stegia Ilicis Fr., *H.*
Coccomyces coronatus (Schum.) de Not., *S.*
Rhytisma acerinum (Pers.) Fr., *L.*, *H.*, *S.*, *F.*

PHYCOMYCETES.

Spinellus fusiger (Link) van Tiegh., *H.*

SPHAEROPSIDALES.

Phoma samararum Desm., *S.*
Macrophoma Fraxini Delacr., *H.*
Septoria Violae Westd., *H.*

HYPHOMYCETES.

Aegerita candida Pers., *F.*
Oidium alphitoides Griff. & Maubl., *S.*, *F.*
Ovularia obliqua (Cooke) Oud., *H.*, *S.*, *F.*
Botrytis cinerea Pers., *S.*
Trichoderma viride (Pers.) Fr., *H.*, *F.*
Ramularia acris Lindr., *H.*, *F.*, lactea (Desm.) Sacc., *S.*, Taraxaci Karst., *S.*, variabilis Fuck., *S.*
Sepedonium chrysospermum (Bull.) Fr., *S.*
Bispora monilioides Corda, *S.*
Cercospora Mercurialis Pass., *F.*
Stilbella erythrocephala (Ditm.) Lind., *H.*
Tilachlidium tomentosum (Schrad.) Lind., *H.*, *S.*, *F.*
Isaria farinosa Fr., *H.*

MYCETOZOA FOUND DURING THE BETTWS-Y-COED FORAY.

September 23rd to 26th, 1924.

By G. Lister.

Our four days' search in the neighbourhood of Bettws-y-Coed yielded a number of exceptionally interesting Mycetozoa. Notwithstanding the heavy rainfall of the preceding days, and much rain falling also on September 24th, thirty-seven species were obtained, nine of which and one variety appear to be new records for Wales. The most prolific hunting-grounds were afforded by large heaps of old sawdust, formed chiefly from coniferous wood. On them were found *Fuligo septica*, *Lycogala epidendrum*, *Hemitrichia Vesparium* and three species of *Cribraria*. *Cribraria argillacea* was developing from dark lead-coloured plasmodium; *C. vulgaris* var. *aurantiaca* from yellow plasmodium which changed to green as the sporangia began to form, and *C. piriformis* from pale slate-coloured plasmodium*: this, on being brought indoors, continued to creep on the surface of the sawdust for nearly a fortnight, throwing up irregular lobes and columns before forming sporangia, which were at first greyish-white, then dark brown and finally, on drying, pinkish brown.

On wet mossy rocks abundance of the bright yellow plasmodium and brown sporangia of *Badhamia rubiginosa* var. *globosa* were found, together with *Lamproderma columbinum* var. *brevipes*, both species being in their usual habitat; *Hemitrichia leiotricha* was also obtained on wet moss. On exposed rock and dead leaves were found several masses of the confluent form of *Stemonitis fusca* var. *trechispora*; the capillitium and columellae are imperfectly developed, and the spores, which measure 8 μ, are marked with bands forming a wide reticulation. The sharply reticulated spores of this variety are often associated with imperfectly developed capillitium; it has also been observed that after the clustered sporangia have been exposed to rain while maturing, they not infrequently assume a confluent form: it is possible, therefore, that the previous wet weather may account in some measure for the present irregular development. Three species of *Didymium* and *Comatricha lurida* were obtained from a thick bed of decaying holly leaves. *Cienkowskia reticulata* was found on a fallen oak bough, maturing from orange plasmodium; part of it, on being brought indoors, continued to creep about in a moist chamber for ten days longer, and then

* The colour of the plasmodium of *C. piriformis* was first observed by Mr N. G. Hadden, near Porlock, Somerset, in July, 1924.

developed into a group of both simple and branched plasmodiocarps; the walls are marked with characteristic shining crimson patches, which when still moist appeared as prominent convex pink warts; they consist of some waxy substance as they stain deep crimson on being treated with alkannin. Similar waxy deposits occur on the sporangium walls of *Trichia Botrytis* var. *cerifera* and in the stalks of *Diachea cerifera*. *Cienkowskia reticulata*, though widely distributed, has been recorded only three times previously in the British Isles, namely, from Cornwall, Leicestershire and Aberdeenshire. Two other rare species obtained on the Foray were *Diderma lucidum* and *Amaurochaete cribrosa*. Of the former species four sporangia were found on decayed wood near Bettws-y-Coed, only a few miles from Trefriw, the locality where it was first discovered in 1860; *Diderma lucidum* has since been seen repeatedly in wooded glens in Merionethshire; apart from these Welsh gatherings, it has been recorded only from Ceylon. Two aethalia of *Amaurochaete cribrosa* were found on fir bark. This is the fourth record of the species in Britain; although widely distributed it appears to be nowhere common. It is distinguished from the more abundant *A. fuliginosa* (Sow.) Rost. by having smaller aethalia, and more regular capillitium which forms a loose elastic network of slender arching threads. A piece of decayed wood, overgrown partly with moss, partly with gelatinous algae, was brought back from near the Swallow Falls, and kept moist, as it seemed a likely habitat for *Colloderma oculatum*, and on it, two months later, November 24th, two sporangia of this species made their appearance.

In the following list of our gatherings the species marked with an asterisk are new records for Wales:

Badhamia rubiginosa (Chev.) Rost.
Physarum nutans Pers. and the var. leucophaeum Lister.
Fuligo septica (L.) Gmel.
F. muscorum Alb. & Schw.
*Cienkowskia reticulata (Alb. & Schw.) Rost.
Leocarpus fragilis (Dicks.) Rost.
Diderma deplanatum Fries.
D. lucidum Berk. & Broome
Didymium nigripes Fries.
D. melanospermum (Pers.) Macbr. var. minus Lister.
D. squamulosum (Alb. & Schw.) Fries.
*Colloderma oculatum (Lippert) Lister.
*Stemonites fusca Roth and var. trechispora-confluens Lister.
Comatricha nigra (Pers.) Schröter.
C. laxa Rost.
*C. lurida Lister.
Lamproderma columbinum (Pers.) Rost. var. brevipes G. Lister.
*L. echinulatum Rost.
*Amaurochaete cribrosa (Fries) Sturgis.
Cribraria argillacea Pers.

C. vulgaris Schrad. var. aurantiaca Lister.
*C. piriformis Schrad.
Reticularia Lycoperdon Bull.
Lycogala epidendrum (L.) Fries.
Trichia persimilis Karsten.
T. varia Pers.
T. decipiens (Pers.) Macbr.
T. Botrytis Pers.
*T. floriformis (Schwein.) G. Lister.
Hemitrichia Vesparium (Batsch) Macbr.
*H. leiotricha Lister.
*H. abietina (Wigand) Lister.
Arcyria ferruginea Sauter.
A. cinerea (Bull.) Pers.
A. pomiformis (Leers) Rost.
A. denudata (L.) Wettstein.
A. incarnata Pers.

MYCETOZOA FROM MATLOCK.

By W. T. Elliott.

The following is a list of Mycetozoa collected at the Matlock Spring Foray, 1924:

Ceratiomyxa fruticulosa Macbr.
Physarum nutans Pers.
P. compressum A. & S.
Didymium squamulosum Fr.
Comatricha nigra Schr.
C. typhoides Rost.
Leocarpus fragilis Rost.
Reticularia Lycoperdon Bull.
Lycogala epidendrum Fr.
Trichia varia Pers.
Trichia persimilis Karst.
T. Botrytis Pers.
T. decipiens Macbr.
T. contorta Rost.
Hemitrichia Vesparium Macbr.
Arcyria cinerea Pers.
A. incarnata Pers.
Perichaena corticalis Rost.
P. depressa Lib.

BETTWS-Y-COED LICHENS.

By H. H. Knight, M.A.

The River Conway on which Bettws-y-Coed is situated divides the two counties of Carnarvon and Denbigh. The greater number of the Lichens on this list are from the former county, but on the second day of the Foray we crossed the Conway, and collected some Lichens on the Denbigh side of the river. The more important of these have the letter *D* after the name. With the exception of *Cladonia uncialis* and *Umbilicaria*, which were brought in from a distance, all the Lichens on this list were found within two miles of our headquarters. Several calcareous Lichens were noticed; these came from mortared walls. In one place on the main road to Capel Curig *Gyalecta cupularis* was plentiful on the shaded side of the wall, both on mortar and rock.

The following Lichens were found fertile: *Parmelia physodes, P. fuliginosa, Pertusaria globulifera, Phlyctis argena.* I am indebted to Mr Paulson for help in compiling this list.

Sphaerophorus melanocarpus Schaer.
S. globosus Wain.
Placynthium nigrum S. F. Gray
Collema pulposum Ach.
C. cheileum Ach.
C. granuliferum Nyl.
Leptogium turgidum Cromb.
L. lacerum S. F. Gray
Parmeliella corallinoides A. Zahlbr.
P. plumbea Wain.
Pannaria rubiginosa Del. var. conoplea Koerb.
Massalongia carnosa Koerb.
Peltigera canina Willd.
P. rufescens Hoffm.
and var. praetextata Nyl.
P. scutata Koerb.
P. polydactyla Hoffm.
P. horizontalis Hoffm.
Nephronium lusitanicum Nyl.
Sticta fuliginosa Ach.
S. limbata Ach.
Lobaria scrobiculata DC.
L. laciniata Wain.
L. pulmonaria Hoffm.
Parmelia physodes Ach.
P. pertusa Schaer.
P. perlata Ach.
and var. ciliata Schaer.
P. saxatilis Ach.
and forms furfuracea and panniformis
P. sulcata Tayl.
P. dubia Tayl.
P. hyperopta Ach.
P. laevigata Ach.
P. revoluta Floerke
P. conspersa Ach.
and var. stenophylla Ach.
P. omphalodes Ach.
P. Delisei Nyl., *D.*
P. fuliginosa Nyl.
and var. laetevirens Nyl.
Cetraria glauca Ach.
and var. fallax Ach
C. aculeata Fr.
Evernia prunastri Ach.
Ramalina farinacea Ach.
Usnea florida Web.
and var. hirta Web.
U. plicata Web.
Placodium citrinum Anzi
P. ferrugineum Hepp. var. festivum A. L. Sm.
P. rupestre Branth. & Rostr.
Candelariella vitellina Müll.-Arn.
Physcia grisea A. Zahlbr.
Physcia stellaris Nyl. var. aipolia Nyl.
P. orbicularis Nyl. var. virella Dalla Torre & Sarnth.
Rinodina demissa Arn.
Lecanora muralis Schaer
L. subfusca Ach. var. chlarona Ach.
and var. allophana Ach.
L. campestris B. de Lesd.
L. coilocarpa Ach.
L. atra Ach.
L. conferta Nyl.
L. galactina Ach.
L. varia Ach.
L. symmicta Ach.
L. piniperda Koerb.
L. sulphurea Ach.
L. polytropa Schaer.
L. intricata Ach.
L. badia Ach.
L. tartarea Ach.
L. subtartarea Nyl.
L. parella Ach.
L. gibbosa Nyl.
L. lacustris Th. Fr.
L. Dicksonii Nyl.
Acarospora fuscata Th. Fr.
Haematomma ventosum Massal., *D.*
Pertusaria globulifera Nyl.
P. faginea Leight.
P. lactea Nyl.
P. pertusa Dalla Torre & Sarnth.
P. dealbata Cromb.
and f. corallina Cromb.
P. leioplaca Schaer.
P. Wulfenii DC.
Thelotrema lepadinum Ach.
Phlyctis argena Koerb.
Diploschistes scruposus Norm.
Crocynia lanuginosa Hue
Umbilicaria pustulata Hoffm.
Baeomyces rufus DC.
Stereocaulon pileatum Ach., *D.*
S. coralloides Fr.
S. paschale Fr., *D.*
Cladonia sylvatica Hoffm.
C. uncialis Web.
C. pyxidata Hoffm.
C. fimbriata Fr.
and var. simplex Wain.
C. cervicornis Schaer.
C. gracilis Willd.
C. furcata Schrad.
C. squamosa Hoffm.
C. caespiticia Floerke
C. digitata Hoffm.
C. flabelliformis Wain.
C. macilenta Hoffm.

Cladonia Floerkeana Fr. var. carcata Wain
Coenogonium ebeneum A. L. Sm.
Gyalecta cupularis Schaer.
Lecidea Friesii Ach.
L. confertula Stirt., *D.*
L. lucida, Ach.
L. quernea Ach.
L. coarctata Nyl.
L. fuliginea Ach.
L. protrusa Fr.
L. parasema Ach.
L. contigua Fr.
L. sorediza Nyl.
L. crustulata Koerb.
L. confluens Ach.
L. lapicida Ach.
L. lithophila Ach.
L. plana Nyl.
L. lactea Floerke
L. fuscoatra Ach.
L. rivulosa Ach.
Biatorella pruinosa Mudd
Biatorina lutea Arn.
B. atropurpurea Massal.
B. lenticularis Koerb.
Bilimbia sabulosa Massal.
B. sabuletorum Branth & Rostr.
Bacidia arceutina Branth. & Rostr. var. hypnaea A. L. Sm.
B. umbrina Branth. & Rostr.
Buellia myriocarpa Mudd
B. impressula A. L. Sm.
B. disciformis Mudd
B. parmeliarum Oliv. on Parmelia saxatilis
Leciographa parasitica Mudd on Pertusaria Wulfenii
Rhizocarpon Oederi Koerb.
R. geographicum DC.
R. viridiatrum Koerb.
R. petraeum Massal. and var. excentricum A. L. Sm.
R. confervoides DC.
Arthonia radiata Ach.
Opegrapha atra Pers.
O. betulina Sm.
O. vulgata Ach.
O. zonata Koerb.
Graphis elegans Ach.
Graphina anguina Müll.-Arg.
Dermatocarpon miniatum Th. Fr.
Normandina pulchella Cromb.
Verrucaria submersa Schaer.
V. nigrescens Pers.
Acrocordia biformis Arn.
Arthopyrenia punctiformis Arn.
A. pyrenastrella Oliv., *D.*
A. cinereopruinosa Koerb., *D.*
A. analepta Massal., *D.*
Porina chlorotica Wain.
Pyrenula nitida Ach.

STUDIES IN ENTOMOGENOUS FUNGI.

(With 1 Text-fig.)

VIII. NOTES ON BEAUVERIA.

By T. Petch, B.A., B.Sc.

In 1835, Balsamo-Crivelli described, under the name *Botrytis Bassiana*, a fungus which was parasitic on the silkworm, the larva of *Bombyx mori*, in Italy, where it caused a disease known as Calcino, because of the chalky appearance of the insects attacked. A paper dealing with this disease was published by Vittadini in 1851; and subsequently the fungus was studied by de Bary, who gave a full account of its morphology and mode of parasitism in his paper, "Zur Kenntnis insektentödtender Pilze," in 1867. In France, the disease of silkworms caused by this fungus is known as Muscardine, from the supposed resemblance of the affected insect to a sugared almond.

In 1891, Delacroix described a similar species, which occurred on a cockchafer, as *Botrytis tenella* and, with Brongniart, another species on the migratory locust of Algeria, as *Botrytis Acridiorum*.

Brongniart, however, had previously published an account of the fungi parasitic on the migratory locust, in which he referred to the latter species as *Botrytis* with round spores, and to another species as *Botrytis* with oval spores; and in including these two in the *Sylloge Fungorum*, x (1892), Saccardo had named the first of them *Botrytis Delacroixii* and the second *Botrytis Brongniartii*. Saccardo's name, *Botrytis Delacroixii*, stands, as the name *Botrytis Acridiorum* had previously been applied to another fungus by Trabut.

Shortly after the publication of the name *Botrytis tenella*, Giard showed that this fungus had been described by Link as *Sporotrichum densum* in 1809. Giard adopted the name *Isaria densa* (Link) Fr., as the fungus may produce coremia.

In *Fungi Italici* (1881), Saccardo had figured a *Botrytis tenella* Sacc. This was described as a subspecies of *Botrytis Bassiana* in *Sylloge Fungorum*, IV, p. 119 (1886). It had globose spores, and is evidently quite different from *Botrytis tenella* Delacr. But Saccardo did not figure the typical conidial heads of the *Botrytis Bassiana* group, nor did he mention them in his description. His illustration shows quite a different type of conidiophore. Hence it is doubtful whether this species is allied to *Botrytis Bassiana*.

Meanwhile, in South America, Spegazzini had described another member of this group in 1880 as *Sporotrichum globuliferum*. This had been found on the coleoptera, *Monocrepidium* sp. and *Naupactus xanthographus*, in the Argentine; and it was subsequently recorded from the same country on *Gargaphia* (*Hemiptera*). In the same paper, Spegazzini described *Sporotrichum minutulum* on larvae of *Fidicina bonaerensis* (*Cicadae*), and in 1881 or 1882, *Sporotrichum minimum* on *Atta lundii* Guer. (*Formicae*), from the Argentine, but from the descriptions it would appear that these two are not similar to *Botrytis Bassiana*.

The name *Sporotrichum globuliferum* Speg. has usually been employed in America for fungi of this group, *e.g.* for the fungus of the chinch bug (*Blyssus leucopterus*).

In 1895, Pettit published an account of cultures he had made of several species of entomogenous fungi. Among these were *Sporotrichum densum*, of which a pure culture had been obtained from Paris, where the fungus was then being sold for destroying cockchafer grubs; *Sporotrichum globuliferum* Speg., found on a Carabid beetle in the United States; *Sporotrichum globuliferum* Speg., on the chinch bug from Kansas; *Sporotrichum globuliferum* Speg., on *Vespa* sp. from the United States; *Sporotrichum minimum* Speg., on a black ant, *Camponotus*, from Ithaca; and a new species, *Isaria vexans*, on *Lachnosterna* (*Coleoptera*), from Ithaca. Pettit placed the last species in

Isaria because it formed coremia, following Giard. It would seem doubtful whether his *Sporotrichum minimum* was identical with Spegazzini's.

Another species was added to this group in 1911, when Beauverie described *Botrytis effusa*, the red muscardine, on the silkworm. Silkworms attacked by this fungus acquire a red tint at one stage of the disease, but it was styled the red muscardine, chiefly because, when cultivated on potato, it colours the potato red. Morphologically it resembles *Botrytis Bassiana*, differing in forming a dense floccose growth in culture.

In the following year, Saccardo described *Botrytis Melolonthae*, found on *Melolontha vulgaris* in Italy. It was said to differ from *Botrytis tenella* in having oval spores. Evidently *Botrytis tenella* Sacc. was meant. The description of the spores agrees with those of *Botrytis tenella* Delacroix, *i.e. Sporotrichum densum* Link; but, as in the case of *Botrytis tenella* Sacc., it is not evident from the description that *Botrytis Melolonthae* belongs to the group under consideration.

In 1923, Bally described *Botrytis Stephanoderis*, on *Stephanoderes hampei* in Java. He had compared the Javan species in culture with *Botrytis Bassiana* obtained from the Centraalbureau voor Schimmelcultures at Baarn, and decided that the two were different, though the differences were quantitative rather than qualitative. *Botrytis Stephanoderis* grew more luxuriantly in culture, formed larger heads of spores in which the spores remained longer attached, and produced coremia regularly on potato.

It will have been noted that European mycologists have followed Balsamo in referring species of this group to *Botrytis*, while American mycologists have agreed with Link that they should be included in *Sporotrichum*. But they do not fit well in either genus; and in 1912 Vuillemin instituted for them a new genus, *Beauveria*, in which he placed the species

Beauveria Bassiana (Bals.) Vuill. = *Botrytis Bassiana* Bals.
Beauveria densa (Link) Vuill. = *Sporotrichum densum* Link
= *Botrytis tenella* Delacr.
Beauveria effusa (Beauv.) Vuill. = *Botrytis effusa* Beauv.

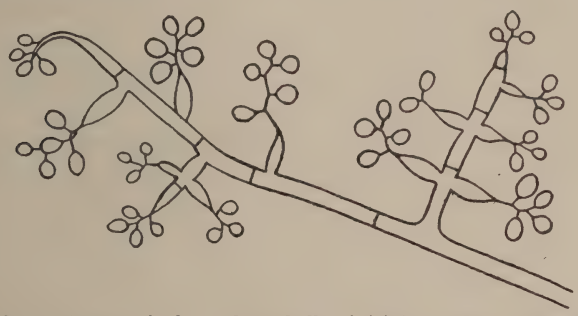
Picard, who published a paper on entomogenous fungi in 1914, transferred Spegazzini's species to the new genus as

Beauveria globulifera (Speg.) Pic. = *Sporotrichum globuliferum* Speg.

Morphology.

The species of *Beauveria* which are found on insects have hyaline hyphae, white or pale yellow in mass, or in some cases and on some media pinkish or reddish in part. In culture, the mycelium is at first loose, and floccose or tufted. Some forms, on the development of conidia, sink into a continuous pulveru-

lent layer; others remain floccose, or after the first formation of conidia and the production of a uniform stratum of spores resume their mycelial growth and fill the tube with woolly masses of hyphae. This secondary growth occurs to some extent in all the strains or species which I have had in cultivation. In those which, as a whole, cease growth after the production of the pulverulent layer of conidia, it takes the form of scattered tufts of hyphae, or of definite compact coremia; in the others, as already stated, the secondary growth covers the original conidial surface with thick woolly mycelium, which fills the tube, sometimes producing loose, somewhat indefinite, coremia. This secondary growth is the more remarkable in that it occurs when the media are drying out.



Text-fig. 1. *Beauveria* from *Oecophylla*: initial stages of formation of conidial heads (branches in excess of two at a whorl omitted). × 1000.

The conidia are borne in loose, globose heads, either on the main hyphae or on short lateral branches. In the latter case, the branch terminates in an elongated, flask-shaped or subcylindric phialide (basidium). Below this, two or more lateral branches more or less at right angles to the primary branch are produced in a whorl; these also terminate in phialides, and may bear branches in the same manner as the primary branch. This process is repeated several times, but it is impossible to determine the limits of the repetition. At any stage, phialides may be produced instead of lateral branches.

Each phialide bears a slender sterigma at the apex, or sometimes two. Bally has figured two in some instances in *Botrytis Stephanoderis*, and I have noted two in *Sporotrichum globuliferum*. After the formation of the first conidium, the sterigma gives off a branch a little distance below it on which another conidium is produced, and this process is repeated until a cyme of conidia is formed, the conidia being arranged alternately on short pedicels on a slender axis. The axis or sterigma is only about 0·5 μ in diameter, and is usually zig-zag or flexuose. This

slender cymose sterigma is the distinguishing character of the genus *Beauveria*.

In general, the conidia do not readily fall off. In *Botrytis Bassiana* they fall off apparently more easily than in other species, and it is possible in that species to find sterigmata from which all but the terminal two or three conidia have disappeared (de Bary; Bally). But in the tropical forms, the conidia usually remain attached for a long time. Immediately on examining one of these fungi it is observed that the head does not break up when mounted, nor do the phialides separate if it is subjected to pressure. Treatment which would resolve the head of, say, a *Sterigmatocystis* into fragments has little effect on the head of a *Beauveria*. The phialides, the long sterigmata, and the persistent conidia form a complex in which it is impossible to trace the arrangement of the separate parts.

De Bary showed that when the conidia are germinated in a thin film of water, the germ tubes, after they have attained a length of six to ten times the diameter of the spore, produce conidia of a different shape and in a different manner. The apex of the hypha becomes attenuated and abstricts a single conidium, or a small head consisting of a few conidia is formed. These conidia differ from the normal conidia, in the first place, in that they lack separate pedicels; they are free on the apex of the sterigma and disperse readily. In the second place, they are not globose, but oblong-cylindric, about the same diameter as, or slightly narrower than, the globose conidia, and three to four times as long. De Bary named these conidia, cylinder conidia. He added that cylinder conidia were produced in the foregoing manner at the apex of germ tubes which remained entirely submerged in water; and also that if the conidia were germinated in a sugar solution or weak gelatine, the germ tubes branched in the culture medium and produced cylinder conidia, both at the apices of the hyphae and on short sterigmata at the apices of the lateral branches. After the formation of cylinder conidia, the hyphae continued their growth and produced normal heads of globose conidia.

The formation of cylinder conidia was observed by Pettit. With regard to *Beauveria densa*, Pettit stated that elongate spores were thrown off in the agar from the ends of short branches, in contrast to the production of conidia on flask-shaped basidia (phialides) on the aerial mycelium. In the case of *B. globulifera*, he wrote: "In three days cylindrical conidia are thrown off in the agar from the terminations of slender threads. After about four days after sowing, conidia are borne outside the agar. The sterigmata [*i.e.* phialides] are terminal or sessile on the ends of short branches. The sterigmata are tipped

with small spherical conidia." Pettit did not describe the typical, slender, cymose sterigma of *Beauveria*, though there are indications of it in his figures (*e.g.* No. 84, and the unnumbered figure to the left of that).

Recently, Dufrenoy has called attention to the same phenomenon in *Beauveria globulifera*, and has added further details concerning the variation in the mode of production of the conidia. He states that the hyphae at first may bud off large, oval conidia, or may produce small conidia apically on cylindrical phialides. Subsequently swollen phialides are produced, with the typical, thread-like, *Beauveria* sterigma, and these may become forked, yielding several sterigmata, or may be grouped in pairs on the vegetative hyphae, or may be grouped into a head at the apex of a differentiated phialidiferous hypha.

Classification.

The morphological differences between the alleged species of *Beauveria* which are parasitic on insects are very slight, according to the published descriptions. Practically the only tangible difference is that, apart from the cylinder conidia, some have globose conidia and others have oval conidia. That, however, is not absolute. The species with globose conidia have the majority of their conidia globose, but a large percentage broadly oval; while those with oval conidia have some conidia globose. A Ceylon species which has the majority of its conidia globose, 1·2–1·75 μ diameter, has some conidia broadly oval, 1·5–2 × 1·2–1·5 μ; and another, in which the majority are oval, 2–3·5 × 1·5–2 μ, has a few globose, 1·5 μ diameter. The shape and size of the conidia do not vary on the different culture media which have been tried.

Beauveria Bassiana, according to de Bary, has globose conidia, 2·5–2·8 μ diameter. Delacroix gives 2–2·5 μ. But Sawada (*Descriptive Catalogue of the Formosan Fungi*) figures them as globose or broadly oval; and in a culture of this species from the National Collection of Type Cultures, they are broadly oval, 1·5–2·5 × 1·2–2 μ or globose, 1·5 μ diameter.

On the spore character, the recorded species may be classified as follows:

Conidia globose: *Beauveria Bassiana* (Bals.) Vuill.; conidia 2·5–2·8μ (de Bary); 2–2·5μ (Delacr.).
B. Delacroixii (Sacc.); conidia 2–2·5μ (Delacr.).
B. globulifera (Speg.) Picard; 2–2·5 × 1·5–2μ (Speg.); 1·75–2·5μ (Pettit).
B. vexans (Pettit); conidia nearly spherical (Pettit).
B. effusa (Beauv.) Vuill.; conidia as in *B. Bassiana* (Beauverie).
B. Stephanoderis (Bally); conidia 2–3μ (Bally).

Conidia oval: *B. densa* (Link) Vuill.; conidia 2·5–3 × 1·5–2μ (Delacr.).
B. Brongniartii (Sacc.); conidia 4 × 2·5μ (Sacc.).

As already noted, there is a marked difference in the habit of these fungi in nature or in culture; and this difference has been utilised in the separation of species. Some species cover the insect with an even, finely pulverulent layer which has a chalky appearance, *e.g. B. Bassiana*. Others cover the insect with a loose cottony or woolly mycelium. This difference may be reproduced in culture; Picard states that cultures of *B. densa* are distinguished from *B. Bassiana* by being cottony, not chalky.

In cultures, this difference is well marked on the production of conidia. Growth on the agar, etc. is of course hyphal or tomentose at first. When the conidia are formed, the heads may be produced in such numbers that they cover the whole of the surface of the culture with a continuous stratum which entirely hides the hyphae except at the margin. In *B. Bassiana*, the heads are small, and consequently the surface appears chalky, *i.e.* finely pulverulent, like the surface of a newly-broken piece of chalk. But in the allied tropical species, the conidial heads are larger, and the surface is mealy or coarsely pulverulent.

In cultures of some species, the conidia occur in scattered masses united by fine strands of hyphae. A similar appearance results when the conidial heads are produced on a rather loose weft of mycelium. This appearance will be designated cottony.

Other species produce in culture dense floccose masses resembling cotton wool, or thick locks of true wool. As a rule these species produce conidia only on part of the culture; or if the whole slant bears conidia, it is subsequently overgrown by dense floccose masses. This type of culture will be designated woolly.

The presence or absence of coremia is not a constant character. De Bary and Delacroix both obtained coremia in *Beauveria Bassiana*. But Bally did not observe them in that species, and makes their absence one of the distinguishing characters between *B. Bassiana* and *B. Stephanoderis*.

In the absence of any well-marked morphological characters, the practice has been adopted of differentiating between species biologically, *i.e.* by the colours produced in culture on certain media, viz. on potato and on gelatine. This again is not altogether satisfactory. Picard notes that the colour is not constant with repeated subcultures, and states that this is an advantage, as the disappearance of the power of imparting a colour to the medium coincides with a loss of virulence of the fungus as a parasite on insects. It is, however, a decided disadvantage, if species are to be identified by the colours they produce.

Picard gives the following key to four of the European species:

Mycelium mealy or chalky	... ...	... ...	*B. Bassiana*
Mycelium floccose or cottony	Spores oval	Potato coloured lie de vin, and gelatine red	*B. densa*
	Spores globose	Potato coloured red. Gelatine not coloured	*B. effusa*
		Neither potato nor gelatine coloured	*B. globulifera*

To the above may be added the following details, derived from the published accounts and descriptions:

B. Bassiana.	Does not colour potato: colours gelatine light chestnut (Delacroix).
B. effusa.	Differs from *B. Bassiana* only in its floccose mycelium and in producing a red colour on potato (Beauverie).
B. Delacroixii.	Does not colour potato: colours gelatine pale fugacious rose (Delacroix).
B. globulifera.	Colours potato purple, or slightly purple (Pettit).
B. vexans.	Colours potato distinctly purple; fructification exactly the same as in *B. globulifera* (Pettit). This is probably only a coremioid form of Pettit's *B. globulifera.*
B. Stephanoderis.	No colours recorded.
B. densa.	Colours gelatine and potato intense red (Delacroix); colours potato deep purple-red and gelatine deep vinaceous purple (Pettit).
B. Brongniartii.	Resembles *B. densa,* but does not colour gelatine red (Delacroix).

With regard to *Beauveria densa*, it may be noted that no two of the three observers cited are entirely in agreement, though Pettit worked with a culture of *B. densa* obtained from Paris.

Picard differs from Pettit as regards *Beauveria globulifera.* This species was introduced from North America into Algeria in 1892, and was distributed for the purpose of destroying *Haltica ampelophaga.* No appreciable result was observed in the following three years; but in 1896 a *Beauveria* was found on *Haltica* and this was considered to be the introduced American species. Subsequently it was introduced into France (from Algeria), without any immediate result. In 1911–12, however, an epidemic of *Beauveria* occurred on *Haltica ampelophaga* in the district into which the Algerian fungus had been introduced, and the species was again identified as *Sporotrichum globuliferum.* The accounts of French investigators relate to this re-discovered species, and, as will be evident from the results recorded in this paper, there is room for doubt whether the French *B. globulifera* is the same as Pettit's, and whether either of them is, biologically, *Sporotrichum globuliferum* Speg.

Material.

Specimens of *Beauveria* have been found in Ceylon on a Phalangid; on a Locustid, *Aularches miliaris*; on an undeter-

mined Curculionid; on a queen red ant, *Oecophylla smaragdina*; on the red coconut weevil, *Rhynchophorus ferrugineus*; on a Chrysomelid, *Metriona circumdata*; on a *Mantis*; and on an undetermined fly. In each case, only one example has been found. The first six agree in the shape and size of their conidia, which are globose, 1·5–2 μ diameter, or broadly oval, 1·5–2·5 × 1·2–2 μ. The seventh and eighth, on a *Mantis* and a fly respectively, have oval conidia, 2–3·5 × 1·5–2 μ, with a few globose, 1·5 μ diameter.

On all these insects, the heads of conidia occur chiefly in bands along the joints. The fungi on *Aularches* and *Rhynchophorus* are coarsely pulverulent, cream-coloured. Those on *Oecophylla*, *Metriona* and *Mantis* are cottony, loosely pulverulent, cream or pale buff; while that on a fly is similar but white. That on a Curculionid is woolly, coarsely pulverulent along the joints, but forming a continuous stroma on the under surface.

A specimen of *B. globulifera* on *Gargaphia*, kindly furnished by Dr Spegazzini, is cottony, forming a loose covering round the outer edge of the insect. This is an old specimen, no longer viable.

B. Bassiana has been recorded on silkworms, etc. in India, but I have not been able to obtain a specimen.

Specimens of *B. Stephanoderis* on *Stephanoderes hampei* were kindly forwarded by Dr K. Friederichs. These, however, had been baked to prevent any possible introduction of the insect, and consequently are not viable. The growth of the fungus is scanty, cream-coloured and cottony. The conidia are globose, 1·2–2·5 μ, or broadly oval, 2–2·5 × 1·5–2 μ. This species evidently belongs to the *B. Bassiana* group.

With the foregoing were sent untreated examples of a *Beauveria* on a Halticid on *Vigna oligosperma*, as the same species. The latter, however, though similar in appearance to *B. Stephanoderis*, has oval conidia, 2·5–4 × 1·5–2 μ, with some globose, 1·2–2·5 μ diameter. It belongs to the *B. densa* group.

Viable examples of *B. Stephanoderis* were subsequently obtained through the kindness of Dr H. Begemann.

The first six of the Ceylon forms agree in spore characters with *B. globulifera*, the spores of which were given originally as globose or globoso-elliptic, 2–2·5 × 1·5–2 μ. But those on *Aularches*, *Rhynchophorus*, and the Curculionid differ from the available specimens of that species in the character of the mycelium. The seventh and eighth Ceylon forms agree with *B. densa* in having oval spores, the dimensions of which are almost identical with those given by Delacroix for that species, viz. 2·5–3 × 1·5–2 μ.

Cultures.

Of the Ceylon forms on a Phalangid, a Locustid, and a Curculionid, only old herbarium specimens were available. The first had been preserved in formalin, while the second and third were seven years old and their conidia did not germinate. The specimen on *Oecophylla* was obtained in April, 1922, and was taken into culture on November 24th of the same year. That on *Rhynchophorus* was collected on October 22nd, 1922, and was taken into culture on the same date as the previous specimen. Both these had been kept in an air-tight box with calcium chloride. The specimen on *Mantis* was collected at the end of February, 1923, and was taken into culture on March 10th, 1923. That on *Metriona* was collected at the beginning of September, 1923, and was taken into culture on September 9th. The first comparisons of this series were made on parallel cultures during September—December, 1923; consequently the various forms had been in cultivation for different periods. They had been subcultured at intervals of about two months. With these were compared *B. Bassiana* and *B. densa*, kindly supplied by the National Collection of Type Cultures.

The specimen on a fly was collected in April, 1924, and was taken into culture on April 11th. That on a Halticid from Java was received in July, 1924, and was taken into culture on July 11th. Parallel cultures of these and the forms previously taken into cultivation were run on maize meal agar, gelatine, and Raulin neutral agar in July and November, 1924.

Viable specimens of *B. Stephanoderis* were received in 1925, and this species was taken into culture on February 2nd. Parallel cultures of all the forms were again run on maize meal agar, and of those longest in cultivation on all the other media.

Cultures were begun by plating out on maize meal agar. In general, and in all the later subcultures, transfers in successive subcultures of one strain were made to all the media from one of the maize meal agar tubes of the previous subculture. In the earlier stages of the work, transfers were made to each medium from the previous subculture on that medium, but this method was abandoned, probably prematurely, as the results appear to indicate. Stock cultures were maintained on maize-meal agar.

The following media were used, with agar, in tube cultures:

Naegeli's fluid, No. 3, with cane sugar; *p*H 6·2–5·9.

Raulin's fluid, original formula; *p*H about 3 (the indicators available did not permit a lower determination).

Neutral Raulin's fluid (Guéguen, *Bull. Soc. Myc. France*, XIV, p. 205); *p*H 6·2–6·1.

Dox's solution, with sodium nitrate and cane sugar; *p*H 7·1–6·5.

Maize-meal; *p*H 5·5 approx.

Cultures were also made on gelatine, 25 per cent., *p*H 5·2, and, in the earlier stages, on 10 per cent. gelatine; the latter was not solid at Peradeniya.

The two figures for the *p*H represent two determinations, one on the medium freshly made, the other after keeping for a month. These were kindly determined by Dr C. H. Gadd.

The tubes were kept with the surface of the slant horizontal, at the temperature of the laboratory (73°–83° F.).

Cultures were also made on potato slabs, sterilised, in Roux tubes.

In doubtful cases the colour of the agar was ascertained by removing the whole slant from the tube (after a brief immersion in hot water), cutting off the agar and placing it on white paper.

Final comparisons were usually made at the end of a month.

Maize-meal agar.

The fungus from *Oecophylla* formed an even, cream-coloured pulverulent layer. In the original culture, strands of white mycelium spread over the glass. White coremia up to 4 mm. high developed in some cultures. When old, the conidial layer was frequently interrupted by minute white tufts of mycelium. The agar was not reddened.

The fungus from *Rhynchophorus* was similar to the foregoing, but no coremia were produced. The agar was not reddened.

The fungus from *Metriona* gave a growth of the same character as the previous two, without coremia. The agar was not reddened.

Beauveria Stephanoderis formed an even pulverulent layer, slightly zoned, cream-coloured, inclined to yellow. The agar was reddened, especially towards the base of the slant. The culture differed from that of the fungus on *Oecophylla* in its colour, and in colouring the medium.

B. Bassiana, when first received, formed an even, white, chalky layer. No coremia were produced, and the agar was not reddened.

B. densa produced a growth indistinguishable from that of *B. Bassiana*, except slightly inclined to cottony at the upper edge. The agar was reddened.

The fungus from *Mantis* formed a dense, woolly growth, yellowish in colour. Loose club-shaped processes arose from the base of the slant and almost filled the tube. Conidia were at first produced in a continuous, pulverulent, yellow layer at the

apex of the slant. Subsequently they were produced anywhere on the mycelium, but not in continuous masses. Subcultures were made on maize-meal slants, a month old, and consequently partly dried out. In these the growth at first resembled that of the previous strains, a yellow, even, pulverulent layer of conidia being formed; but, subsequently, dense woolly masses of mycelium were produced, which covered the original growth and filled the tube. The agar was reddened.

The fungus from a fly gave a zoned, cream-coloured, pulverulent growth at first. Scattered tufts of mycelium subsequently developed, and these became pink, or salmon pink when in contact with the glass. The agar was reddened. In old cultures, the tufts became compact and pulvinate.

The fungus from a Halticid gave a thin, cottony growth, zoned at distant intervals with narrow bands of spore masses. The colour was distinctly lemon-yellow, and the agar was reddened. The growth of this fungus was less vigorous than that of any of the others. Coremia were produced at the top of the slant after three months.

Thus, on maize-meal agar, the growth of the *Oecophylla*, *Rhynchophorus* and *Metriona* strains was practically the same; the culture was pulverulent and cream-coloured, and the agar was not reddened. *B. Bassiana*, which belongs to the same group morphologically, gave a white, finely pulverulent or chalky growth, and did not redden the agar. But *B. Stephanoderis* differed from all the foregoing in reddening the agar.

The strain from *Mantis* gave a woolly growth, with yellow pulverulent spore masses. That from a fly gave a zoned, cream-coloured pulverulent growth, and that from a Halticid, a scanty, zoned, cottony, lemon-yellow growth. In *B. densa*, which is morphologically the same as these three, the culture was white, and finely pulverulent. All four agree in reddening the agar, but they differed markedly in the colour and appearance of the cultures. With reference to the zonation of certain cultures, it is to be noted that all were equally exposed to the light.

Naegeli agar.

The fungus from *Oecophylla* produced a thin, flat, cream or pale yellow, pulverulent layer. The reverse was pale yellow or pale buff, and the agar was not coloured.

The fungus from *Rhynchophorus* made a similar growth, but deep cream or deep buff. The reverse was buff, becoming orange-red. The agar was not coloured.

The *Metriona* fungus showed a more extensive growth than the previous two, but of the same character, and cream coloured. The reverse was pale yellow. The agar was not coloured.

Beauveria Stephanoderis gave a thin, cottony, pale cream layer, the reverse being orange-yellow. The agar was not coloured.

B. Bassiana gave a thin, white, pulverulent layer. The reverse was pale yellow, tending somewhat to orange-yellow. The agar was not coloured.

B. densa formed a thin, white, pulverulent layer, orange-red on the reverse. The agar was not coloured.

The growth of the *Mantis* fungus was similar to that of the first three, intermediate in extent between that of the first two and the third, and repeatedly zoned. The reverse at the end of a fortnight was orange-red with a yellow margin, but at the end of three weeks it had changed to a muddy olive-brown. The agar was coloured green or yellowish green.

The fungus from a fly gave a thin, cottony, pale cream growth, in diffuse patches, sometimes circular and zoned. The reverse was muddy red-brown in the centre, but elsewhere the growth was scarcely dense enough to show any colour. The agar was not coloured.

The Halticid strain formed a poor, flat, yellowish, cottony growth. The reverse was cream-coloured at first, becoming reddish, and finally changing to pale brown. The agar was not coloured.

All the strains grew poorly on this medium, a very thin, but usually opaque, stroma being produced. The *Mantis* strain was constantly, and the strain from a fly sometimes, zoned. Only the *Mantis* strain coloured the agar. On this medium, the *Rhynchophorus* strain differs from the *Oecophylla* and the *Metriona* strains in the colour of the reverse.

Raulin-neutral agar.

The fungus from *Oecophylla* formed a fairly thick, even, cream or pale yellow, pulverulent layer, with a rather broad, white, advancing margin. When old the culture became wrinkled. At the end of three weeks, deep yellow, terete, conical clavae appeared, arising from a deep yellow patch in the middle of the pulverulent spore layer. These clavae extended to the upper side of the tube, where they divided into strands spreading over the glass. The reverse of the culture was deep purple-red, fading subsequently to a muddy red with an orange margin in contact with the glass. The agar was not coloured.

The fungus from *Rhynchophorus* produced a similar growth, cream to pale yellow, but without clavae. The reverse was deep purple-red, fading to yellow with purple-red patches. The agar was coloured a deep purple-red or claret colour, this being the most intensely coloured culture of this series. The colour

ultimately became more concentrated in a transverse band at the level of the lower edge of the stroma.

The fungus from *Metriona* produced a dense, woolly mycelium, filling the lower part of the tube and covering the upper part of the slant with a loose fluffy white layer. At the end of a month, the upper part of the slant was a continuous, buff, pulverulent layer, while the lower part of the tube was stuffed with pale yellow, woolly mycelium, tinged pink here and there. The reverse was pale yellow to brownish yellow, becoming pale chestnut, and the agar was coloured yellow-brown.

Beauveria Stephanoderis produced a convoluted, deep cream, pulverulent layer, subsequently developing a white fluffy growth in the centre. The reverse was orange-yellow at first, becoming red-brown. The agar was not coloured. No coremia were produced.

B. Bassiana gave a white, even, pulverulent growth. The reverse was chestnut, and the agar ultimately became slightly yellow-brown.

B. densa gave a similar white pulverulent layer. The reverse was purple-red, and the agar was coloured purple-red, especially in a transverse band at the lower edge of the stroma.

The *Mantis* fungus produced at first a thick stroma, over about one-half the slant, pulverulent and buff in the centre, with a broad, cushiony, yellow, tomentose border. The stroma then developed a dense, woolly mycelium, pale yellow in colour, covering the masses of conidia and filling the lower part of the tube. Loose clavae were formed at the edge of the stroma. The reverse was purple-red, the agar becoming purple-red or claret-coloured.

The fungus from a fly gave an extensive compact stroma, convoluted in the centre, pulverulent, at first cream, becoming pinkish buff. Large woolly tufts developed subsequently in the centre and these were pinkish. The reverse was yellow at first, becoming yellow-brown to chestnut. The agar was coloured red-purple, especially in a band at the lower edge of the stroma.

The superficial growth of the Halticid strain was scanty. A fairly extensive mycelium developed within the agar, but the superficial growth was limited to small areas and was white and cottony. The submerged mycelium viewed from above was dull orange-yellow. The reverse was at first reddish yellow, becoming yellowish red to purple-red. The agar was coloured slightly purple-red, with a denser band at the lower edge of the stroma After two and a half months, the general surface growth was the same, but yellowish coremia were developing from various parts of the slant, with woolly masses here and there.

On this medium, the two European fungi retained their white

colour. The strains from *Oecophylla*, *Stephanoderes* and *Rhynchophorus* exhibited the same type of growth, but only the first produced clavae and only the last coloured the agar. The *Metriona* fungus departed from these two in its woolly growth and the coloration of the reverse and the agar. The *Mantis* fungus agreed with *B. densa* in its coloration of the agar, but differed in its woolly growth and the colour of the spore masses. That from a fly differed from all others in its pinkish buff spore masses, while the Halticid species differed in its habit of growth. The latter was so markedly different from that of this form on other media, and of all other strains, that contamination was suspected. The cultures, however, proved on examination to be *Beauveria*, and further cultures from stock on this medium gave the same type of growth.

Raulin agar.

This strongly acid medium did not become solid at Peradeniya. Growth occurred as floating islands of mycelium of various sizes, which ultimately coalesced into a more or less continuous stroma covering the surface of the liquid.

The fungus from *Oecophylla* formed a thick, continuous, irregularly wrinkled, cream-coloured, pulverulent stroma. The reverse was at first yellow, becoming purple-red with a yellow margin. The agar was not coloured.

The growth of the fungus from *Rhynchophorus* was similar, but the pulverulent spore masses were buff. The reverse was deep purple-red and the agar similarly coloured, the coloration being equal to that on Raulin-neutral agar.

The fungus from *Metriona* produced thick, fleecy masses of mycelium, which ultimately settled down into a more or less compact mass, covered with pale cream, pulverulent spore masses. The reverse at first varied from yellow to pinkish buff, and finally became yellow-brown to clay-coloured. The agar was tinged greenish yellow.

Beauveria Stephanoderis gave a good growth, pulverulent, cream-coloured, the reverse being yellow to orange-yellow. The agar was not coloured.

B. Bassiana gave a white chalky stroma. The reverse was orange-yellow in contact with the glass, yellow on the floating patches, the latter finally becoming isabelline in the centre. The agar was not coloured.

B. densa gave a white growth, pulverulent in the centre, but very woolly at the margin. The reverse was pale purple-red to blood-red, and the agar was not coloured.

The fungus from *Mantis* filled the tube with deep cream-coloured floccose masses of mycelium, salmon pink to carmine

at the edge of the slant. Conidia were produced in visible quantity only in a patch at the apex of the slant in deep cream-coloured masses. The reverse was reddish purple, and the agar was reddened.

The fungus from a fly gave a cream-coloured pulverulent stroma, with finally a slight woolly new growth. The reverse was pale purple-red at first, and finally red-brown. The agar was slightly coloured reddish brown.

The fungus on a Halticid produced floating pulvinate patches which coalesced slowly. After two and a half months the stroma was continuous, but thin, and the white spore masses did not hide the medium. The reverse was reddish yellow, and the agar was not coloured.

In general the characters on this medium ultimately resembled those on Raulin-neutral agar. The fungus on *Metriona* again gave a woolly mycelium, and differed from all the others in the colour of the reverse and of the agar. The growth of the Halticid fungus was again poor.

Dox agar.

The fungus from *Oecophylla* formed a thin, even, white, pulverulent layer. The reverse was flesh-coloured, and the agar was not coloured.

The fungus from *Rhynchophorus* gave a similar growth, cream to deep yellow. Subsequently, white tufts of mycelium developed and the culture became white, cottony, with deep yellow, pulverulent patches. The reverse was purple-red, and the agar was coloured slightly purple-red, the colour ultimately disappearing.

The fungus from *Metriona* produced a flat, but generally woolly, growth, pale yellow, varying finally from woolly to pulverulent. The reverse was yellow, becoming pinkish buff, and the agar was not coloured.

Beauveria Stephanoderis gave a thin, cottony, cream-coloured layer, the reverse being pale yellow. The agar was not coloured.

B. Bassiana formed a flat, compact, white, pulverulent layer. The reverse was pale orange and the agar was not coloured.

The growth of *B. densa* was similar to that of *B. Bassiana*. The reverse was brownish red, and the agar was slightly reddened.

The fungus from *Mantis* formed an even, flat, pulverulent layer, white, ultimately interrupted by yellow tufts. The reverse was deep reddish purple, and the agar reddish purple or claret-coloured.

The fungus from a fly covered the slant with a flat pulverulent stroma, at first cream, becoming pale yellow or greenish

yellow. The reverse was at first cream, then pale salmon, and then vivid carmine. At the end of a month the agar became reddish purple, with a concentration of colour at the base of the slant. After five weeks, the reverse of the upper part of the slant became yellow, and this change extended downwards slowly. New tufts of mycelium varied from white to pink.

The fungus on a Halticid gave a thin, cottony, white growth. The reverse was pale yellowish red, becoming purple-red, and the agar was slightly reddened. After two months, the cultures produced coremia at the sides of the slant, and woolly masses at the apex.

The most notable features of this series were the white spore masses in the cultures of the *Oecophylla* and *Mantis* strains, and the carmine reverse of the fly strain.

Gelatine.

Cultures were made on 10 per cent. and 25 per cent. gelatine. The former was semi-fluid at Peradeniya. In general, growth on the 25 per cent. was better than on 10 per cent. gelatine.

The fungus from *Oecophylla* produced a deep yellow woolly growth, but not extending far above the medium. The reverse was pale yellow to orange-yellow, and the gelatine was not coloured.

The fungus from *Rhynchophorus* formed a flat, pulverulent, cream-coloured layer. The colour of the reverse varied. In one series on 25 per cent. gelatine, it was pale ochraceous, with a faint reddish tinge in the lower part of the slant, while in another series it was yellow to orange-yellow, without any red tinge. On 10 per cent. gelatine, it was pale yellow to buff, with a small red patch at the point of inoculation. The gelatine was not coloured.

The fungus from *Metriona* produced a loose and cottony growth in the upper part of the slant, but a more woolly growth below. The reverse was pale yellow to orange-yellow, and the gelatine was not coloured.

Beauveria Stephanoderis formed a pale cream, cottony growth. The reverse was pale yellow at first, becoming pale purple-red in the centre. The gelatine was not coloured.

B. Bassiana gave a white, pulverulent layer in the first cultures, the reverse being yellow. The gelatine was not coloured. After three subcultures, the spore masses were cream.

B. densa gave a similar growth, the spore masses being somewhat scattered at the margin. The reverse was at first white, then became pale purple-red in the centre, and ultimately purple-black, all the mycelium in the medium also turning purple-black. The gelatine was not coloured.

The fungus from *Mantis* gave a flat, pulverulent, deep cream layer, inclining to woolly at the margin. The reverse was deep reddish purple, and the gelatine reddish purple (claret-coloured).

The fungus on a fly gave a pinkish buff pulverulent layer. The reverse was purple-red, and the gelatine was faintly coloured purple-red.

The Halticid strain gave a scanty, cottony, white growth. The reverse was yellowish red, and the gelatine was slightly reddened.

B. Bassiana, *B. Stephanoderis* and the allied strains from *Oecophylla*, *Rhynchophorus* and *Metriona* did not colour gelatine. *B. densa*, which, according to European investigators, should colour gelatine, failed to do so; it is possible that the available strain may have lost that property by repeated cultures. The *Mantis*, fly and Halticid strains, which are allied to *B. densa*, coloured gelatine, but the two last-named only slightly.

The fungus on *Oecophylla*, which gives a pulverulent growth on other media, became woolly on gelatine. It was not at first possible to distinguish *B. Bassiana* from *B. densa* by the appearance of the culture, except by the colour of the reverse, but after three subcultures, the spore masses of *B. Bassiana* became cream-coloured.

In all strains, the stroma tends to become funnel-shaped on gelatine, and if a red or purple colour is produced it usually appears first at the base of the funnel.

Potato.

Slabs of potato were sterilised in Roux tubes.

The *Oecophylla* and *Rhynchophorus* strains, within a week, formed a thin, even, cream-coloured covering of conidia over the whole surface. The potato was not coloured. The *Rhynchophorus* strain developed coremia at the end of a month, the stalks being deep yellow where they adhered to the glass.

Beauveria Stephanoderis produced a similar growth, somewhat thicker. The potato was not coloured.

The *Metriona* strain formed fluffy tufts of white mycelium with few conidia. After three weeks, the culture was still in this condition, but at the end of a month the upper part had collapsed into a loose cobwebby mass of mycelium and spores, while loose clavae, slightly pinkish in colour, arose from the base of the substratum, filling the lower part of the tube. The potato was not coloured.

B. Bassiana gave a flat, white, chalky growth, thicker than that of the *Oecophylla* and *Rhynchophorus* fungi. It was confined to the potato, which was not coloured.

B. densa gave a copious, white, woolly growth, partly filling

the tube. The coloration of the potato varied. In one series on Indian potato, a section of the slab showed a concave coloured zone, deep purple, becoming purple-red on exposure. Subsequently, owing to the difficulty of obtaining Indian potatoes free from *Bacillus Solanacearum*, Scotch potatoes were used, and the slabs of these were coloured uniformly purple throughout in the same time, the colour remaining unchanged on exposure.

The strain from *Mantis* enveloped the potato with a dense woolly growth which filled the lower part of the tube. This was white, with a pink tinge here and there. The potato was not coloured. No masses of conidia were evident at the end of a month.

The fungus from a fly gave a growth similar to that from *Mantis*, with a pink to salmon-pink tinge, more developed than in the latter. The potato was not coloured.

The Halticid strain gave an even, pulvinate, deep yellow growth over the potato, not extending to the wall of the tube. Except in colour, the growth resembled that of the *Oecophylla* strain. The potato was coloured pale reddish purple.

It is to be noted that the character of the growth in the several strains does not agree with their division into two groups on morphological characters. *B. Bassiana*, *B. Stephanoderis* and the *Oecophylla* and *Rhynchophorus* strains produce a flat growth, and *B. densa* and the *Mantis* and fly strains a woolly or cottony growth. But the *Metriona* strain, which belongs morphologically to the first group, produces a growth similar to those of the second group, while the Halticid strain, which belongs morphologically to the second group, produces a growth similar to those of the first group.

None of the *B. Bassiana* group colour potato. Of the *B. densa* group, two colour potato, but the other two do not, though they develop colour in the mycelium.

The Character of the Mycelium.

As the primary distinguishing character between the different species of *Beauveria*, the form of the mycelium has been employed, that of *B. Bassiana* being chalky, and that of *B. densa*, *B. effusa* and *B. globulifera* being cottony or floccose. Practically this difference is due to the relative quantities of conidia and hyphae produced. In some instances, the mycelium is relatively scanty and the conidia form a continuous powdery stratum which completely hides it; in others, the mycelium may be scanty or profuse, but in either case the conidial heads are relatively fewer and scattered. It has been claimed that this difference is maintained in culture, cultures of *B. Bassiana* being immediately distinguishable from those of *B. densa*.

The appearance in culture may vary with the age of the culture. The fungus from *Oecophylla*, when grown on gelatine, forms a pulverulent layer when the conidia are first formed, and then develops a woolly growth. Again, the fungus from *Mantis*, which has usually a woolly mycelium, forms at first a continuous pulverulent stratum, if grown on rather dry maize-meal agar, but develops a woolly mycelium later.

The appearance, in culture, at the end of a month, of the species or strains grown in the present investigation was, in the earlier stages of the work, as follows:

	Maize	Gelatine	Naegeli	Raulin neutral	Raulin	Dox	Potato
Oecophylla	mealy	woolly	mealy	mealy	mealy	mealy	mealy
Rhynchophorus	mealy	mealy	mealy	mealy	mealy	cottony	mealy
Metriona	mealy	woolly	mealy	woolly	mealy	woolly	cottony
Stephanoderis	mealy	cottony	cottony	mealy	mealy	cottony	mealy
Bassiana	mealy	mealy	mealy	mealy	mealy	mealy	mealy
densa	mealy	mealy	mealy	mealy	woolly	mealy	woolly
Mantis	woolly	mealy	mealy	woolly	woolly	mealy	woolly
Fly	mealy	mealy	cottony	mealy	mealy	mealy	woolly
Halticid	cottony	cottony	cottony	cottony	cottony	cottony	mealy

Only one of the nine, viz. *B. Bassiana*, retained the same growth character in all cultures. Contrary to the European accounts, it was not possible to distinguish *B. Bassiana* from *B. densa* by the type of growth on gelatine, though they differed on potato and on Raulin agar.

On Naegeli agar, on which growth was generally poor, all the strains were mealy or cottony; but on gelatine, on which growth was also poor, both the *Metriona* and the *Oecophylla* strains were woolly. This was the only medium, of those used, on which the *Oecophylla* strain was woolly. It will be evident that, in general, the type of growth of a given species of *Beauveria* is not constant, provided that a sufficiently extended range of media is employed.

On the character in question no two of nine strains could be regarded as the same.

The Coloration of the Medium.

The table on p. 264 gives the colour of the medium in the different cultures in the earlier stages of this investigation.

The fungus from *Oecophylla* was the only one which did not, at first, colour the medium in any culture, though *B. Bassiana* nearly approaches it in that respect, the colour imparted to Raulin-neutral agar by the latter being slight and tardily developed. *B. densa* did not colour gelatine in this series of cultures; this may have been due to the fact that it had been in culture for a long period, though, on the other hand, it coloured maize-meal, Raulin-neutral, Dox and potato. In

general, the species with oval spores, *e.g. B. densa* and the strain from *Mantis*, produce the strongest coloration, but the form from *Rhynchophorus* gives quite as deep a colour on Raulin-neutral.

TABLE.

	Maize	Gelatine	Naegeli	Raulin neutral	Raulin	Dox	Potato
Oecophylla	—	—	—	—	—	—	—
Rhynchophorus	—	—	—	purple-red	purple-red	slightly purple red	—
Metriona	—	—	—	yellow-brown	greenish yellow	—	—
Stephanoderis	reddened	—	—	—	—	—	—
Bassiana	—	—	—	slightly yellow-brown	—	—	—
densa	reddened	—	—	purple-red	—	slightly reddened	purple-red or purple
Mantis	reddened	reddish purple	green	purple-red	reddened	reddish purple	—
Fly	reddened	purple-red	red-brown	chest-nut	red-brown	reddish purple	—
Halticid	reddened	reddened	pale brown	purple-red	reddish yellow	purple-red	reddish purple

In this connection, the coloration of the reverse of the culture should also be considered. It is, indeed, questionable whether it is legitimate to distinguish in all cases between the coloration of the reverse of the culture and the general coloration of the medium. Lack of time has prevented an investigation of the mode of origin of the colouring matter, and its relation to the salts, etc. used in the culture media. But it would appear probable that the coloration of the reverse is due in some cases to the production of a colouring matter which remains in the stroma, while the coloration of the medium is due to an excess of the same colour which diffuses through the medium.

On Raulin-neutral agar, the strain from *Rhynchophorus* coloured the agar deep purple-red, that from *Mantis* coloured it a paler purple-red, while that from *Oecophylla* did not at first colour the agar. But in all three the reverse was purple-red, though differing in intensity. It might, therefore, be supposed that in the *Rhynchophorus* strain, an excess of pigment was produced which diffused into the medium; in the *Mantis* strain, less of the pigment, but still an excess which diffused; but in the *Oecophylla* strain, all the pigment was retained by the mycelium. The differences between these strains, as regards this character, would then be differences of degree.

That view, however, does not agree with all the recorded observations. In the case of the *Mantis* strain on Naegeli agar,

the colour which diffuses into the medium is not the same as that of the reverse. In the strain from a fly on Dox agar, the reverse was carmine, while the agar was coloured purple-red. But in the latter, at the end of a month, the colour began to concentrate at the bottom of the tube, leaving the reverse of the upper part of the slant pale yellow. On the other hand, when the reverse is reddish purple and the agar is not coloured, the reverse usually fades in course of time to a muddy flesh colour; the colour does not concentrate.

In *Beauveria densa* on gelatine, the reverse became pale purple-red in the centre and ultimately purple-black. The gelatine was not coloured, but the mycelium in it was purple-black. As *B. densa* is said to colour gelatine, there is consequently some doubt whether this effect would not be regarded as fulfilling that condition.

On potato, neither the *Mantis* nor the fly strain coloured the substratum. But both produced a pink coloration in the mycelium in contact with the potato.

The Impermanence of Cultural Characters.

In September, 1924, transfers were made from the stock cultures, which had been previously transferred in May. It was then noted that the growth of the *Oecophylla* strain was different, the mycelium being matted and compact, and bearing comparatively few conidia, and that the maize-meal agar was reddened. Parallel transfers of the *Rhynchophorus* and *Metriona* strains did not colour maize-meal agar. The *Oecophylla* and *Rhynchophorus* strains had then been in culture twenty-two months.

Transfers of the *Oecophylla* and *Rhynchophorus* strains at the end of December, 1924, gave the same result; and, in consequence, parallel cultures of the four original strains, viz. those on *Oecophylla*, *Rhynchophorus*, *Metriona* and *Mantis*, were made in January, 1925, from the stock cultures of May, 1924, on all the media except Raulin agar. It was then found that the reactions of these strains were not in all cases the same as when they were originally taken into culture.

On maize-meal agar, the *Oecophylla* strain formed a matted, compact layer, white to cream, with comparatively few conidia, and the agar was reddened. On Naegeli agar, the growth was poor, white and cottony, instead of cream-coloured and mealy, and the reverse became orange-red. On Raulin-neutral agar, the growth was cream-coloured and pulverulent, as before, and the reverse purple-red, but the agar was coloured, chiefly in a deep red purple zone towards the base of the slant. The growth on Dox agar and on gelatine was the same as before, and the fungus did not colour potato.

The *Rhynchophorus* strain still produced a deep cream-coloured mealy growth on maize-meal agar, but the agar was reddened, either generally or in patches. On Dox agar the reverse was yellowish red, instead of purple-red, and the agar was not coloured. On the other media, the characters were the same as in the initial cultures, except that the coloration of Raulin-neutral agar was not so intense as previously. This strain had been in culture for twenty-six months.

The *Metriona* strain gave a felted compact growth on maize-meal agar, similar to that of the *Oecophylla* strain, but it did not colour the agar. On Dox agar, the growth was still woolly, but after five weeks it was yellow only in the centre, and the reverse was orange-yellow, instead of pinkish buff. On other media the reactions were unchanged. This strain had been in culture for sixteen months.

The *Mantis* strain showed no change on maize-meal agar. On Raulin-neutral agar the coloration of the medium was less intense. On Naegeli agar, the reverse was red-brown, instead of olive-brown, and no green colour was obtained in the medium. This strain had been in culture for twenty-two months.

The salts used in the cultures were taken from the same stock throughout. The maize used in the later cultures was the yellow flint, commonly grown in Ceylon, whereas that used in the earlier cultures was a white dent. To ascertain whether the observed changes on maize-meal agar were due to the maize, cultures of all strains were run on maize-meal agar made from the white dent maize in February, 1925. The *Oecophylla* and *Rhynchophorus* strains again reddened the agar, though not so intensely as in the yellow maize-agar cultures.

Thus both the *Oecophylla* and *Metriona* strains showed a reduction in their capacity to produce conidia when grown on maize-meal agar, though they still produced a thick layer of conidia on other media. The other changes in the four strains were principally reductions in the intensity of the coloration of the agar, as has been previously recorded for species of *Beauveria* in Europe. But both the *Oecophylla* strain and the *Rhynchophorus* strain acquired the property of reddening maize-meal agar, and the former that of colouring Raulin-neutral agar.

Further, *Beauveria Bassiana*, which produced white chalky spore masses in culture when first received in December, 1923, gave a pale cream pulverulent growth in September, 1924, the conidial heads being larger than in the original culture. No change was observed in *B. densa*.

Consequently, the colour of the spore masses of a *Beauveria*, or the coloration produced by it in the medium, is not neces-

sarily constant on repeated subculture, and the change may take the form either of a reduction or loss of the original colour, or the acquisition of colour and the power of imparting colour to the medium.

The Parasitism of *Beauveria*.

If the type of growth in culture and the coloration of the different culture media are accepted as specific characters, then all the strains grown in the present series are different species. Hence it might be expected that each species of insect would have its own particular species of *Beauveria* parasitic upon it. Moreover, it is known that certain insects may be attacked by more than one species of *Beauveria*, *e.g.* the larva of *Bombyx mori*, by *B. Bassiana* and *B. effusa*. Consequently there opens up a prospect of an illimitable series of species of *Beauveria*.

On the other hand, it has hitherto been supposed that species of *Beauveria* are pleophagous. Spegazzini recorded *B. globulifera* as occurring on Coleoptera (*Monocrepidium* and *Naupactis xanthographus*) and on a *Gargaphia* (Hemiptera). Billings and Glenn state that the same species was found in North America on Coleoptera (*Trichobasis texana*, *Conotrachelus orinaceus*, *Anthonomus fulvus*, *Disonycha triangularis*, *Hippodamia convergens*, *Olibrus* sp.), on Hemiptera (*Blyssus leucopterus* and three other species), on Phymatidae (*Microtoma carbonaria*, *Coriscus ferus*, and another species), and on many common Pentatomids; while in France it has been recorded on *Haltica ampelophaga* (by Picard and others) and on caterpillars of *Cnethocampa pityocampa* (by Dufrenoy).

Beauveria Bassiana has been recorded on the larvae of *Bombyx mori*, on *Cochylis ambiguella* (by Fron), and on *Nonagria typhae* (by Portier and Sartory).

The foregoing records were, in general, not based on comparative cultures or on infection experiments. Giard, however, infected with *Beauveria densa* the larvae of *Tenebrio molitor*, *Anomala frischii* and *Polyphylla fullo* (Coleoptera); and caterpillars of *Acherontia atropos*, *Sphinx ligustri*, *Mamestra brassicae*, *Brotolomia meticulosa* and *Bombyx mori*. He failed to kill *Schistocerca peregrina*, several species of *Stenobothrus*, *Decticus verrucivorus* and *Locusta viridissima*. On these results *B. densa* can attack Coleoptera and Lepidoptera, but not Orthoptera.

Prillieux and Delacroix, using the same species of *Beauveria*, *B. densa*, successfully infected larvae of *Cetonia aurata* and *Rhizotrogus solstitialis*, and caterpillars of *Euproctis chrysorrhoea*.

Lecœur infected a Coleopteron, *Anthonomus pomorum*, and the chrysalis of a Lepidopteron, *Cheimatobia brumata*, from a culture of *Beauveria densa*.

Pettit did not succeed in infecting larvae of *Lachnosterna* (Coleoptera) with *Beauveria densa*. Working with *B. globulifera* from the chinch bug, he failed to infect *Aphis brassicae* and the larvae of a wireworm, *Agriotes mancus*, and only obtained one successful infection in four attempts on larvae of *Lachnosterna*. Using *Beauveria vexans* from *Lachnosterna*, he infected caterpillars of *Pieris rapae* and *Oedemasia concinna*, but failed with caterpillars of *Cycnia egle* and *Hyphantria cunea*: accidental infections from these cultures occurred on a red ant and on caterpillars of *Melitaea phaeton*.

Picard infected caterpillars of *Phthorimaea operculella* with *Beauveria globulifera*.

Conversely, Delacroix infected caterpillars of *Bombyx rubi* with *Beauveria Bassiana*, *B. densa* (from cockchafers), and *B. Delacroixii* (from a cricket).

Bally, after recording that *Beauveria Stephanoderis* occurred on other species of beetles in addition to *Stephanoderes hampei*, stated that caterpillars of *Cricula fenestrata* had been successfully infected with that fungus both in the laboratory and in the field.

Very many of the records of the host insects of the various species of *Beauveria* are open to question, as the fungi were not subjected to comparative culture. In one instance, it has been found that the fungi determined as the same species on two different insects are morphologically different. But where infection experiments have been attempted, these undoubtedly point to the pleophagy of these fungi, though one might urge as a possible objection the difficulty of obtaining for experiment insects which can be guaranteed sterile. It does not, however, appear probable from the recorded experiments that the parasitism of a given species of *Beauveria* is restricted to one species of insect, or even to one group of insects.

Consequently it is the more surprising that in the series of cultures recorded in this paper, three specimens of *Beauveria* with globose spores, collected by chance, should, if biological differences are considered specific, have proved to be three different species, and different from both *B. Bassiana* and *B. Stephanoderis*; and that the same should have occurred in the case of three specimens with oval spores, viz. those on a *Mantis*, a fly, and a Halticid, all of which, on the same consideration, differ from *B. densa*.

It has already been pointed out that, according to European investigators, the power of colouring the medium is not constant, but is lost by repeated subculturing, at least in *B. densa*. The same was observed in the present series in the case of the *Mantis* strain on Naegeli agar, while a diminution of colour

occurred in the case of the *Rhynchophorus* and the *Mantis* strains on Raulin-neutral agar. But, on the other hand, both the *Oecophylla* and the *Rhynchophorus* strains acquired the power of reddening maize-meal agar, and the former that of colouring Raulin-neutral agar.

It would appear, therefore, that the power of colouring the medium might depend upon the kind of medium on which the fungus had previously grown; and it would seem a legitimate suggestion that the same fungus, after having grown on different insects might produce different colorations of the media.

It is regretted that it has not been possible to obtain further examples of *Beauveria* on *Oecophylla*, etc. in order to determine whether the strains on these insects always produce the same colours in culture, nor to institute cross infection experiments and subsequent cultures with these fungi to determine whether the coloration of the medium varies if the same strain of *Beauveria* is taken into culture from different insects.

Infection experiments were attempted with *B. densa*, obtained from the National Collection of Type Cultures, on larvae of *Bombyx mori*, *Attacus ricini* and *Rhynchophorus ferrugineus*. Sprinkling the larvae with spores and keeping them in a damp chamber was unsuccessful. Direct inoculation by puncturing the larvae with a needle was also unsuccessful, the fungus developing neither on those which survived the operation, nor as a saprophyte on those which died in consequence of it.

Systematic.

The examples of *Beauveria* dealt with in this series of cultures, like the European forms, fall into two groups, viz. one group having conidia chiefly globose, and another having conidia chiefly oval. They thus correspond with *B. Bassiana* and *B. densa* respectively. They differ from those species in having larger conidial heads, which, with one exception, are cream-coloured to pale buff in mass in nature. This colour is, in general, maintained in culture; but the exception noted, viz. the strain on a fly, which is white in nature, gives deeper colours in culture than any other, while some forms which have cream-coloured spore masses in nature become white on certain media, viz. the *Oecophylla* and *Mantis* strains on Dox agar. Moreover, *B. Bassiana* from Europe, when grown on maize-meal agar in Ceylon, forms larger spore heads and becomes cream-coloured on repeated subculture. Consequently, both the size of the spore heads and the colour of the spore mass are variable characters.

From the recorded spore measurements, the forms with globose spores agree with *B. globulifera*, not with *B. Bassiana*. But an examination of European cultures of the latter shows

that this apparent difference is non-existent, the conidia of *B. Bassiana* varying from globose to broadly oval, and thus agreeing with those of *B. globulifera*.

B. Stephanoderis was described as a new species because it had larger conidial heads than *B. Bassiana*, and the conidia were cream in mass. But in the light of the present records, neither of these is a sufficient distinction. It differs from *B. Bassiana*, biologically, in reddening maize-meal agar and in the coloured reverse on gelatine.

The three Ceylon forms with globose spores agree with *B. globulifera* as described by European investigators in not colouring potato or gelatine Pettit, however, stated that *B. globulifera* coloured potato purple. But if the coloration of the medium is a specific character, these three Ceylon forms must be considered distinct from one another.

Of the strains with oval spores, all three colour gelatine to some extent, but only one, that on a Halticid, colours potato. Consequently, only the latter agrees with *B. densa* as recorded, though the strain of *B. densa* available for comparison coloured potato but not gelatine. But the Halticid strain differs from *B. densa* in the character of its growth on potato, while on the total of all the growth characters and colour reactions on different media, all four must be regarded as distinct species, if such characters are considered of specific value.

Cultures of *Beauveria* previously recorded have generally been confined to two media, viz. potato and gelatine, and consequently they do not afford sufficient data for comparison with the present series. Until further evidence is available, it would appear preferable to regard these Ceylon and Javan forms as possibly biologic forms of *B. Bassiana* and *B. densa* rather than to describe them as new species.

These results throw considerable doubt upon the value of the method of determining species of *Beauveria* by their behaviour in culture. They certainly indicate that, if that method is adopted, culture on two media only is inadequate.

Addendum.

Lycogala fragilis Holm (*Vid. Selsk. Skrifter, Nye Samling*, No. 1, Kbn. (1781), p. 288, fig. 5), on a dead cockchafer, was, from the figure and description, probably a *Beauveria*.

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MUTINUS BAMBUSINUS (ZOLL.) ED. FISCHER.

(With Plates XIV–XVI.)

By T. Petch, B.A., B.Sc.

In May, 1912, a single specimen of a *Mutinus* was collected in the Royal Botanic Gardens, Peradeniya. Two years later, in October and November, 1914, the same species appeared in abundance in the decaying debris of an old clump of the Giant Bamboo (*Dendrocalamus giganteus*). From its general shape it was thought to be *Mutinus bambusinus* (Zollinger) Ed. Fischer, and it was recorded under that name in the *Annals of the Royal Botanic Gardens, Peradeniya*, VII, p. 57 (1919).

In August, 1923, this species again sprang up in hundreds in a similar decaying clump of the same bamboo, and as the specimens appeared to present some peculiar features, they were critically compared with the former collections, and with the descriptions and figures of *Mutinus bambusinus*. The gathering of 1923 proved to be the same as those of previous years, but it was found that none of them quite agreed with the published accounts of *M. bambusinus*. Except in one particular, the general appearance of the fungus is the same as that of the latter species, but the structure of the head differs from that described and figured for *M. bambusinus*.

The "eggs" occur in dense clusters. They are small, considering the size of the expanded fungus, oval, about 3·5 cm. high and 2 cm. diameter, sometimes covered above with a grey, tomentose layer, which splits into patches as the egg increases in size.

The expanded fungus (receptaculum) is fusoid in shape and up to 16 cm. high, the head being about one-half the total height. The lengths of stalk and head respectively in a series of specimens were 8 cm., 8 cm.; 8 cm., 7 cm.; 8 cm., 6 cm.; 6 cm., 6 cm.; 5 cm., 7 cm.; 5 cm., 6 cm. The greatest observed difference between the lengths of the stalk and the head was in a specimen 15 cm. high, in which the stalk was 9·5 cm. and the head 5·5 cm.

The stalk is 0·9–1·2 cm. in diameter, attenuated downwards into the volva. It is pinkish above, fading into white below, hollow, with a wall composed of a single layer of large chambers, the exterior walls of which are frequently perforated, while the interior walls are continuous.

The head is elongated conical, sharply defined from the stalk. The diameter of the head, at its junction with the stalk, is

greater than that of the latter, either slightly greater, or exceeding it by 2 mm. The head is not covered with gleba up to the apex, but usually terminates in a sterile tip, up to 5 mm. long. Examples with a bifurcated apex (Plate XV, fig. 2) are not uncommon. When bearing the gleba, the head is dark red or brownish red, but after the gleba has been washed off it is bright crimson. The sterile tip is pinkish in colour, and of the same structure as the stalk. It may be perforated at the apex or not. In general, it is perforated, often laterally compressed with the two sides in contact. In some examples, the tip is almost suppressed, and the head then appears truncate.

The structure of the head differs from that of *Mutinus caninus* and *M. Fleischeri*. The wall is red throughout as in those species, and as in them it has a single layer of large chambers, generally widely perforated on the inner side. But it differs, in that the outer surface bears irregular parenchymatous processes, simple or variously branched, attached to the head and more or less perpendicular to the wall. These are evident in the photograph on Plate XV, fig. 1. The large chambers in the lower part of the figure correspond with those of the head of *M. Fleischeri*, while the processes above are an additional feature, not existing in the latter species. Consequently, whereas the head of *M. Fleischeri* is smooth externally, that of the present species is rough or granular when fresh, or somewhat spongy when drier.

The gleba is dark olive. On small examples, it may form discontinuous, dark olive patches. But, owing to the enormous elongation of the head on expansion, the gleba is usually spread out in a very thin film which does not completely hide the red colour of the underlying tissue. The gleba in the expanded fungus lies to a great extent between the processes of the head. The spores are cylindric or oblong-oval, $2–4 \times 1\,\mu$.

The odour of the fungus is strong, but not unpleasant. It resembles that of some decaying fruits. There is a slight foetid odour apparent when the plant is held very close, but if two or three specimens are kept in a room only an extremely strong, fruity smell is perceptible.

The points in which this fungus appeared to differ from *Mutinus bambusinus*, according to the published descriptions of the latter, are (1) the sterile apex of the head, (2) the structure of the glebiferous region, (3) the colour of the head, and (4) its odour.

The sterile tip is not an accidental feature, due merely to absence of the gleba, as it differs in structure from the glebiferous part of the head.

The descriptions and figures of *Mutinus bambusinus* suggested that that species is a *Eu-mutinus*, with a head similar in structure

to that of *M. caninus*. In the Ceylon species, the head is rough, and similar in character to that of *Pharus Gardneri*, *Clautriavia irpicina*, and the *Rugulosi* section of *Ithyphallus*, though the processes are not so stout as in the first two species. But no details were available concerning the nature of the head in expanded specimens of *M. bambusinus*.

Zollinger's description of *M. bambusinus* (*fide* Fischer) was "Volva coriacea sordide albida irregulariter lacerata, interiore breviore tenuissima alba; stipite tereti roseo deorsum tenuiore et pallidiore elastico cribroso, capitulo stipiti contiguo conico acuto impervio tuberculoso intense purpureo." This agrees with the Ceylon species in shape, having a conical head and a stalk attenuated downwards, and in the colour of the stalk; but it differs in its deep purple, tuberculate head. Whether the apex is closed or open may not be a material character. Zollinger's specimens were collected among dead bamboos at Buitenzorg in Java.

Berkeley recorded *M. bambusinus* in *The Intellectual Observer*, IX (1866), with a copy of a figure by Kurz who had collected the specimens in Java. He stated that it had an elongated conical, subacute receptacle (*i.e.* head in this instance), strongly papillose and of a deep purple-red, and a rose-coloured stem.

In 1885, Fischer published an account of *M. bambusinus* in *Ann. Jard. Bot. Buitenzorg*, VI, based upon material, preserved in alcohol, which had been collected in the bamboo grove of the Botanic Gardens, Buitenzorg, by Solms-Laubach. Fischer described the stalk as pale brownish red and the head as dull purple. In alcohol, the Ceylon fungus retains the crimson colour of the head for some time, while the stalk becomes white. The surface of the head was wrinkled tuberculate, and the length of the head was equal to or greater than that of the stalk. The head was elongated conical, almost of the same diameter below as the stalk. The stalk was cylindric, with a wall composed of a single layer of large chambers, often perforated externally. The structure of the head was similar, but the internal, not the external walls of the chambers were perforated. [This difference is general in *Mutinus*.] The apex of the head was not perforated.

Fischer's figure of the receptaculum (No. 29) shows a specimen 10·5 cm. high, with an elongated conical head, terminating in an acute apex. The head is slightly greater in diameter than the stalk at the junction of the two, and is about one-half the total height of the fungus. The stalk is almost uniformly cylindric. The head is marked with polygonal areas, the outer walls of the chambers of which it is composed. Fischer's description as "tuberculate" apparently refers to these convex outer walls. There is no indication on the figure or in the description of any

projecting processes on the head. But fig. 31, which shows a section of a developing head, strongly suggests that the outer walls of the chambers of the head bore projecting processes in that specimen.

In 1888, Cooke recorded the occurrence of *Mutinus bambusinus* in Britain, specimens having appeared in open ground among young plum trees in Noble's Nursery at Sunningdale. He stated that the fungus had a very strong foetid odour, whereas *M. caninus* was inodorous. The whole fungus was 10 cm. high, and according to Cooke's account the head was acutely conical and half the entire length. But that is so greatly at variance with his figures that it would appear that his description is chiefly a translation of Zollinger's.

Cooke gave coloured figures, including copies of Kurz's drawings and drawings of the British specimens by Massee. Kurz's figures show one specimen just breaking through the volva, and another in which the head has emerged but the stalk is not fully expanded. In the latter the head is 3·3 cm. long and the stalk (at most) 2·5 cm. It is difficult to imagine how Kurz obtained specimens in that state. He must have risen very early in the morning to collect them in that condition, and even then expansion would have continued while he was drawing them. The only explanation which appears at all probable is that the specimens were collected in the egg stage, and began to expand next morning while lying indoors, but had not sufficient moisture to enable them to complete their expansion.

Massee's figure *h* bears some resemblance to *Mutinus bambusinus*, though the head is short, about one-half the length of the stalk, and too convex. But figure *i*, which shows an ovato-conoid head about one-quarter the length of the stalk, is quite unlike any other figure of *M. bambusinus*.

Fischer, after an examination of these British specimens in Herb. Kew, was of opinion (1893) that they were only *Mutinus caninus*. There seems to be no doubt that they are not *M. bambusinus*.

In 1890, Fischer described a new species, *Mutinus Muelleri*, from Brazil, which is apparently closely allied to *M. bambusinus*. It had a conical head and a cylindrical stalk, the length of the head being about one-fourth to one-fifth the length of the stalk. The total height of the fungus was from 2 to 8 cm. The stalk was white or reddish and the head dirty purple-red. From the figures, it would appear that the glebiferous layer extended to the apex, and the apex was generally truncate. The surface of the head was transversely wrinkled, evidently different from that of the stalk, and often sharply limited from the latter by a definite constriction.

Fischer claimed that *Mutinus Muelleri* differed from *M. bambusinus* in the relative lengths of the head and stalk, the colour of the stalk, and in that in *M. bambusinus* the chambering (Kammerung) of the head was less different from that of the stalk than in *M. Muelleri*. Fischer states that in *M. Muelleri* the outer walls of the chambers of the stalk are composed of two to three cell layers, and those of the head of six cell layers, while in *M. bambusinus* the outer walls of the stalk chambers have two to four cell layers and those of the head four to six.

Möller, in 1895, described the same fungus, which he found growing among bamboos in Brazil. He disagreed with Fischer's identification and referred it to *Mutinus bambusinus*, after comparison with the specimens from Java in the Berlin Herbarium which had been examined by Fischer. According to Möller, the fungus may attain a height of 11 cm. and the ratio of the lengths of head and stalk is variable, from one-fifth to a half. The stalk is white, and the head dirty purple-red. The apex is always perforated.

Möller's photograph shows a specimen with a cylindrical stalk and a conical head, the apex being distinctly truncate. A well-marked furrow divides the stalk from the head. The surface of the head is covered with gleba, but the photograph gives the impression that the head is tuberculate under the gleba, the tubercles being the convex outer walls of the chambers of the head. The wall of the stalk is not perforated.

Fischer investigated the young stages of *Mutinus Muelleri*, and found that, contrary to what occurs in *M. caninus*, the tissue which lies between the gleba and the head formed in this species loose spherical cells, and his figure (27) shows these cells in contact in irregular rows. He also made comparisons with the young stages of *M. bambusinus* from Java, and found that the latter had essentially the same structure, but that the spherical cells were less strongly developed. In his key to the identification of the species, Fischer distinguished *M. Muelleri* by its having in the young stage numerous spherical cells between the receptaculum and the gleba.

Fischer stated, with regard to *M. Muelleri*, that when the fungus expanded, the gleba lay directly on the zone formed by the spherical cells, and the latter rested upon the head. But when the spore mass ran off, the spherical cells also for the most part disappeared, so that on examination of specimens which no longer bore gleba, the head was for the most part not covered by loose pseudoparenchyma cells.

Möller stated that spherical cells, loose or united into small parenchymatous masses, occurred in greater or smaller quantity

between the gleba and the head in *M. Muelleri*, but that the amount of these varied in different examples.

Mutinus boninensis, described by Fischer from specimens from the Bonin Islands, is not very different from *M. bambusinus*, according to the figures and description. In its young stage, before expansion, it has a parenchymatous layer between the gleba and the head, which forms a continuous layer over the latter; but what becomes of this layer on expansion was not recorded.

In a recent note on *Staheliomyces cinctus*, Fischer again discusses the processes of the head which occur in several species of phalloids, especially in *Clautriavia irpicina*, and states that in *Mutinus Muelleri* the region between the gleba and the head consists of a loose tissue similar to the pseudoparenchyma of the head.

Penzig, in his paper on the phalloids of Java, stated that *Mutinus bambusinus* was common in Java, but that he refrained from describing it as it was already well known. That was somewhat unfortunate, as he was the first investigator of phalloids who had an opportunity of examining the Javan species in a fresh state.

As regards the odour of these fungi, Möller stated that the odour of *M. Muelleri* was not specially strong and resembled that of fresh horse dung. He also quoted Solms-Laubach that the odour of *M. bambusinus* in Java was weak and very offensive, resembling that of human excrement. Cooke recorded that the alleged British specimens of *M. bambusinus* had a very strong foetid odour, whereas *M. caninus* was inodorous. The Ceylon specimens have a strong odour, but it is not offensive and resembles that of decaying fruits. It is to be expected that opinions on this character will be as varied as those on colours, but nevertheless the recorded observations differ so widely that one would not expect them to relate to the same species.

The colour of the head in *M. bambusinus* is said to be deep purple by Zollinger, and dull purple by Fischer. Möller stated that the head of *M. Muelleri* was dirty purple-red. Fischer recorded that the head of *M. boninensis*, as far as could be determined from specimens preserved in alcohol, was dull red. In the Ceylon specimens, the head, when covered with the gleba, is dark red or brownish red, but after removal of the gleba it is bright crimson.

Whether the perforation of the apex in *Mutinus* is a valid character or not, depends upon the structure of the species. In some species of *Mutinus*, *e.g. M. Fleischeri*, the glebiferous layer extends *over* the apex, and in this species the apex is truly imperforate. On the other hand, in the Ceylon species

under discussion, the glebiferous layer does not extend to the apex, and the tip of the head is composed of tissue of the same nature as that of the stalk. In the latter species the apex may be perforated or not. Möller stated that the apex of *M. Muelleri* was always perforated; the truncate apex shown in his photograph supports his contention, and Fischer's figures show a perforated apex. A similar truncate apex is figured by Fischer for *M. boninensis*. On the other hand, Zollinger described the apex of *M. bambusinus* as imperforate, and Fischer describes and figures an imperforate apex in that species. The difference depends upon the structure of the head. In some species, the glebiferous layer is a continuous conical cap, and in these the head is consequently imperforate; in other species, the glebiferous layer is a cylinder with open ends, and in these the head is perforated at the apex, or is closed by a tissue different from that of the glebiferous layer and resembling that of the stalk.

To decide the identity of the Ceylon species, application was made to Dr C. Bernard, of Buitenzorg, for specimens of *Mutinus bambusinus*, and through his friendly offices, Dr C. van Overeem kindly forwarded examples of that species in alcohol. An examination of these furnished somewhat unexpected results.

The general stature of the Javan specimens is the same as that of the Ceylon examples. One is 7 cm. high, with a head 3·5 cm. long; another, 9 cm. high, has a head 5 cm. long; and a third, 5 cm. high, has a head 1·5 cm. long. The diameter of the head is slightly greater than that of the stalk. In all three, the glebiferous layer does not extend over the apex. The two larger have a distinct sterile tip, while in the smallest the tip is almost suppressed. In two examples the apex is closed, but in the third it is open. Two have lost their colour in alcohol, but the head of the third is bright red. The outer wall of the stalk is perforated.

In one specimen, the head bears irregular processes similar to those of the Ceylon form, but they are not so strongly developed. Here and there they appear to be wanting, so that the outer walls of the chambers of the head are visible as small pulvinate elevations. But on examining these areas with a lens it is seen that they are very minutely granular. In the other two specimens the head appears smooth, and merely bullate and transversely wrinkled, as in *M. Fleischeri*, but on close examination it is found to be minutely granular and to have remains of the processes scattered over the head.

In the Ceylon specimens, the lateral walls of the chambers of the head nearly all attain the same level, so that the inner surface is even, with numerous perforations. In the Javan specimens, the walls of some of the chambers are shorter than

the others, so that when viewed from the inner side, the surface presents numerous large cavities, with a network of ridges at the base. This, however, is not universal in the one specimen, and some sections show a structure exactly the same as that of the Ceylon forms. The walls of the chambers of the head tend to be thicker in the Javan specimens than in the Ceylon ones.

A section of part of the head of a Ceylon example is shown on Plate XVI, fig. 1. Below are the chambers of the head, one of which is closed and the others perforated on the inner side. External to this layer (above in the figure) are numerous parenchymatous masses, with darker masses of gleba between them. These are the sections of the processes, and here and there they can be seen to be attached to the outer wall of the head. They arise from the wall of the head as a sheet of tissue, which divides above into lobes more or less parallel to the head. Hence, in section, some pieces appear to be attached by a definite stalk, while others are sections of the lobes and appear to be loose. The outer surface of the wall of the head is the continuous line across the figure, its angular outline being due in part to contraction in alcohol. When fresh and expanded, the outer walls of the chambers are convex.

Fig. 2, Plate XVI, shows a similar section of a Javan specimen. It will be noted that the walls of the chambers are, in places, thicker than those of the Ceylon specimen, though they vary greatly in that respect. The external processes are feebly developed, and are absent for a short length in the middle of the figure.

Fig. 3, Plate XVI, is another section from the same serial series as the last. In this section, the lateral walls of the chambers on the left are as long as those of the Ceylon specimen, but in the centre they are much shorter. It will, however, be evident from the two sections that this variation in the length of the lateral walls is not a constant feature of the Javan form; and it is not a distinguishing character between the Ceylon and the Javan forms, as it occurs, on a less extensive scale, to the left of the section of the Ceylon example.

Fig. 4, Plate XVI, is a section of another Javan specimen, the head of which appeared smooth. In this the walls of the chambers are short and massive. It is to be noted that all the photographs of sections are taken with the same magnification. The processes in this case are distinguishable only with difficulty. They are almost in contact with the outer wall of the head, with a thin layer of gleba beneath them. The interrupted black line in the figure is the gleba, the processes forming comparatively large parenchymatous masses external to that.

It will be evident that the structure of the head is the same

in both the Javan and the Ceylon examples, the differences being merely of degree. In the available examples of the Ceylon form, the processes of the head are strongly developed and crowded together, so that the outer wall of the head is not visible and the head appears rough when the gleba is removed. In the Javan form, the processes are, in general, not so strongly developed, and they may be widely scattered, or absent over certain areas, so that the head may appear smooth, bullate, and transversely wrinkled, when the gleba is removed.

According to Fischer, the processes on the head of such phalloids as *Clautriavia*, etc. are of the nature of paraphyses, which penetrate between the trama plates of the gleba. Some species do not possess them, and consequently their heads are smooth when the gleba ripens. It would also seem probable that, in those species which possess these paraphysoid structures, the latter might be involved in the deliquescence which occurs in the gleba mass when ripe. In that case one would expect a variation in the degree of development, or rather in the extent of persistence, of these structures. The apparently smooth areas on the head of *Mutinus bambusinus* bear minute points which appear to be the attachments of vanished processes.

The Javan specimens of *M. bambusinus* examined were from Buitenzorg, near sea-level. The Ceylon specimens were from Peradeniya, at an elevation of 1600 ft. It would be of interest to determine whether specimens from the low-country of Ceylon more closely resemble the Javan examples, but up to the present the fungus has not been found in Ceylon except at Peradeniya. It is possible that the difference in mean temperature might have some effect on the development of the fungus, as regards the relative amounts of gleba and paraphyses, or on the deliquescence of parts of the fungus at maturity.

In view of the variation which occurs in *M. bambusinus* from the type locality, there can be little doubt that the Ceylon fungus must be referred to that species. Moreover, it would seem equally certain that *Mutinus bambusinus*, *M. Muelleri* and *M. boninensis* must all be regarded as the same species, the differences recorded being merely minor variations of the same structure.

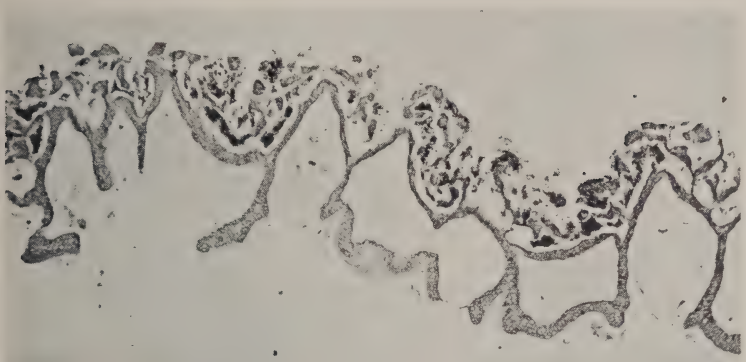
There are two distinct types of structure of the glebiferous layer in the stalked phalloids. In the one type, the head is glabrous, either tuberculate, or regularly reticulated with raised bands. In the other, the head is covered with irregular parenchymatous processes and appears granular. Examples of the two types, parallel as regards general shape, are afforded by *Dictyophora phalloidea* and *Clautriavia irpicina*; by *Lysurus australiensis* and *Pharus Gardneri*; by *Ithyphallus tenuis* and

MUTINUS BAMBUSINUS

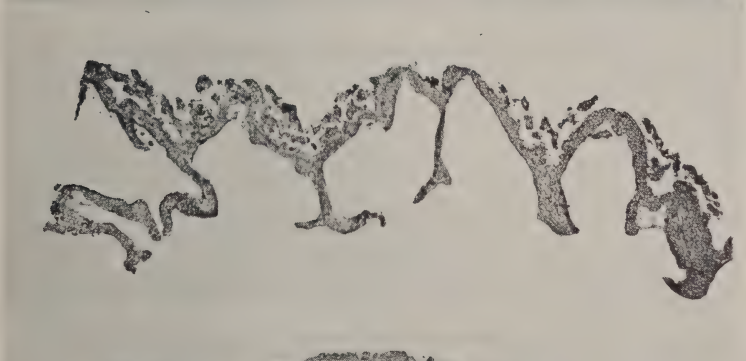
1

2

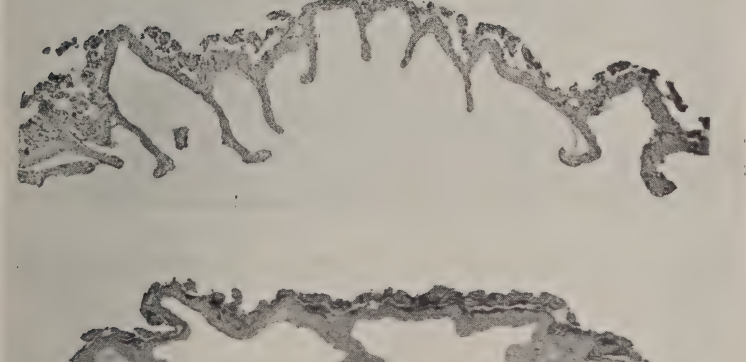
MUTINUS BAMBUSINUS



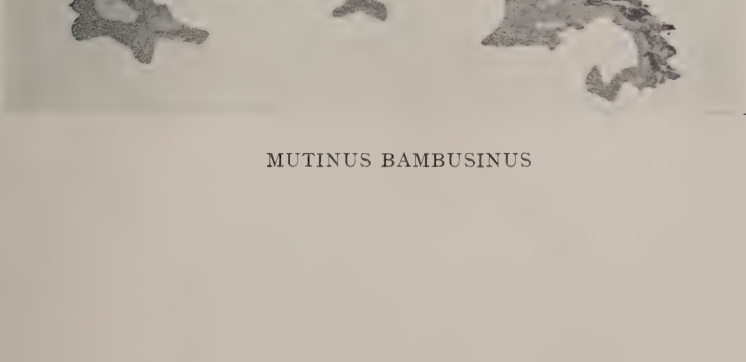
1



2



3



4

MUTINUS BAMBUSINUS

I. rugulosus. The difference is of generic value. It cannot, however, be ascertained until the gleba is removed, and hence many figures of phalloids do not afford sufficient evidence to enable them to be classified even generically.

Mutinus bambusinus, because of the comparatively feeble development of its processes, and their absence in some examples from at least part of the head, provides a link between the two types referred to above. But as the head is furnished with these parenchymatous processes, it should be classed in the second group, not in *Eu-mutinus.*

Penzig proposed the genus *Jansia* for certain species of *Mutinus* in which the head bears projecting appendages. In these species, the appendages are regular, hollow, finger-like outgrowths from the wall of the head, and quite different from the irregular, solid, parenchymatous processes of *Clautriavia irpicina*, *Mutinus bambusinus*, etc. It is not possible to include the present species in *Jansia.* Fischer (1900) placed *Mutinus boninensis* in *Jansia* (as a subgenus), but from his figures and description it differs in structure from Penzig's species.

[*Note.* It has been pointed out to me that the generic name *Pharus*, proposed by me for *Colus Gardneri* in *Ann. Perad.* VII, p. 59, has been applied previously to a genus of North American grasses. Following the usual practice, *Pharus* Petch may be replaced by *Mycopharus.*]

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EXPLANATION OF PLATES XIV, XV AND XVI.

Plate XIV.

Mutinus bambusinus, gleba removed; natural size.

Plate XV.

Fig. 1. *Mutinus bambusinus*, gleba removed; natural size.

Fig. 2. Specimen with a bifurcated apex, gleba removed; natural size.

PLATE XVI.

Fig. 1. Section of the wall of the head of a Ceylon specimen.
Fig. 2. Ditto, specimen from Java.
Fig. 3. Ditto, same specimen as Fig. 2.
Fig. 4. Ditto, Javan specimen macroscopically smooth. All × 20.

FUSARIUM PALLENS (NEES) LINK.

By T. Petch, B.A., B.Sc.

THE present century has witnessed a notable development of what may be termed stock-taking in systematic mycology. The earlier mycologists, working in different countries and with scanty facilities for communication or publication of their descriptions of fungi, each in his separate star described the species which came under his notice, with the natural result that the same species might be described several times under different names. It cannot be claimed that the practice is obsolete at the present day; and a cursory examination of any critical monograph of a limited group of fungi will immediately show how extensive the resulting synonymy has become.

It has been truly said that when Saccardo completed the first eight volumes of the *Sylloge Fungorum* in 1889, the mycological world then had a basis on which to produce lasting work—but failed to rise to the occasion. It has been left to a later generation to attempt the task of weeding out superfluous names; and now that time has diminished the resentment with which the implication that there could be any errors in systematic mycology was at first received, it is becoming recognised that in the conditions under which the subject has grown up, mistakes were inevitable, and if it is to deserve rank as a science these mistakes must be rectified.

One of the chief obstacles in the way of attaining a stable nomenclature in systematic mycology (apart from generic changes) is the interpretation of the descriptions, and consequently the application of the names, of the pioneer mycologists. Descriptions in early days were usually brief, and were drawn up with a view to distinguishing between a few species. Consequently they are inadequate when distinctions have to be made between a score or more species. In some instances the early descriptions are, from the modern standpoint, practically generic descriptions. This of course was scarcely avoidable. It is not given to everyone to write with a knowledge of what will be required a hundred years hence.

In dealing with the species described by Berkeley and other mycologists of his era it is generally possible to decide what was

intended. Berkeley's descriptions are short, after the fashion of that period, and not always sufficient for a definite determination, but in nearly all instances a type specimen is in existence. Even if the type specimen is immature or fragmentary, it may be possible for a specialist in a particular group to recognise it, or for a worker in the district or country in which it was collected to match it with more perfect specimens.

Difficulties arise when, in an endeavour to ascertain the earliest name, we attempt to go further back and interpret the names given by the mycologists of the earlier years of the last century. In perhaps the majority of cases, there does not appear to be any type specimen in existence. In some instances, a trivial name has been generally adopted and consistently applied to one species since its first publication; and with such there is no difficulty. But in other cases, the name never came into general use—the fungus may not have been collected again—and there is consequently no traditional meaning attached to it. For practical purposes, these latter names are *nomina nuda*. Technically, of course, they are not; and if our list of fungi is to represent actual knowledge, it is necessary either to find species to fit them, or to discard them.

My opinion inclines to the view that such unattached names should be discarded. If, however, it is decided to bring them into use, the evidence in favour of their revival should possess a high degree of probability. The species to which it is proposed to apply the name should at least agree closely with the figure, if any, and with the description as far as the latter goes.

A recent publication affords a case in point. Wollenweber, in *Annales Mycologici*, XV, pp. 1–56 (1917), published the results of his examination of a large number of species of *Fusarium* in European herbaria, under the title, "Fusaria autographice delineata." The paper is merely a summary, giving lists of species found to belong to the genus *Fusarium*, with synonyms and generic changes as determined by Wollenweber from the specimens examined by him: the figures and the full data relating to the specimens being deposited in the Office of Cotton and Truck Crop Disease Investigations of the United States Department of Agriculture. Consequently an exact appreciation of the conclusions arrived at is not always possible. The chief point, however, to which it is desired to call attention is the replacement of the name *Microcera coccophila* Desm. by *Fusarium pallens* (Nees) Link, a change which has already passed into use in Europe.

Incidentally, it may be noted that this change abolishes the genus *Microcera* Desm. The type species of that genus is *Microcera coccophila*. Consequently, if *Microcera coccophila* is

merely a *Fusarium*, the genus *Microcera* Desm. lapses. But Wollenweber retains the genus for *Microcera Massariae* Pass. and transfers to it *Fusarium ciliatum* Link, while he accepts as *Microcera*, *Microcera Clavariella* Speg. *Tubercularia ciliata* A. and S. (*Atractium ciliatum* Link) has continuous subcylindric spores, $5 \times 2{\cdot}5\,\mu$; it has generally been regarded as a *Volutella*, *V. ciliata*. Link's genus *Atractium* had continuous spores, though he stated that he had seen septate spores in *Atractium ciliatum*. But the latter species is certainly not related to *Microcera* Desm. Again, *Microcera Clavariella* is a *Cladosterigma*, and differs completely from both *Fusarium* and *Microcera*. No single genus can possibly include *Microcera Massariae* Pass., *Volutella ciliata* (A. and S.) Fr. and *Cladosterigma Clavariella* (Speg.) v. H.

The following specimens are referred to *Fusarium pallens* by Wollenweber. The second column gives the host of the fungus in the specimen examined by him; the third, the name inscribed on the herbarium sheet; and the fourth, the herbarium or collection in which the specimen is to be found:

344.	Cort. Acaciae horridae	Fusisporium coccinellum Kalch.	Cesati, Rome
345.	Ram. Baccharidis dracunc.	Fusarium baccharidicola P. Henn.	Berlin
346.	Cort. Lauri	Microcera coccophila Desm.	Berlin
347.	Cort. Lauri nobilis	Microcera coccophila Desm.	Berlin
348.	Cort. Lauri nobilis	—	Wollenweber
349.	Cort. Populi nigrae	Fusarium pallens Nees	Cesati, Rome
350.	Ram. Robiniae	Fusarium parasiton Fautrey	Upsala
351.	Cort. ram. plantae ignotae	Pionnotes pseudonectria Speg.	Berlin

The data concerning the specimens unfortunately do not include the date or locality of the collection, nor the exsiccati names and numbers. No. 344 is apparently part of the original South African collection, and, as stated in *Trans. British Myc. Soc.* VII, p. 124 (1922), it is probably to be referred to *Microcera coccophila* Desm., though no perithecia have yet been seen from South Africa. But Nos. 346, 347, if, as is usual in European herbaria, these refer to the specimens collected at Florence in 1860-66, are the *Microcera* stage of *Sphaerostilbe aurantiicola*. It is, however, scarcely possible to distinguish these two in the absence of perithecia.

Dr C. Spegazzini has kindly furnished me with the type of *Pionnotes pseudonectria*. The fungus is growing on a scale insect (? *Chionaspis*) which is embedded in the bark and is not evident until the overlying fragments of dead bark are removed. The specimen contains numerous immature examples of a *Nectria* and well-developed synnemata of *Microcera*. It is *Sphaerostilbe flammea*, with its conidial stage, *Microcera coccophila* Desm.

The evidence for the substitution of the name *Fusarium pallens* for *Microcera coccophila* would appear to be that the

specimen under the former name in Cesati's herbarium at Rome is *Microcera coccophila*. But that is not the type specimen. It is quite possible that Cesati's specimen was wrongly named. If the type specimen of *Fusarium pallens* is in existence, it should be examined before that name is adopted; if there is no type specimen, it is necessary to consider very carefully the applicability of the description and figure to the species which is known as *Microcera coccophila*.

Fusarium pallens was described by Nees in *Nov. Act. Acad. Leop. Nat. Cur.* IX, p. 237 (1818), under the name *Atractium pallens*, with a figure, Table V, fig. 7. The description is as follows:

Atractium pallens, nobis. *Bleiche Kopfspindel.* A. erumpens, capitatum, stipite cavo subepidermide latente, capitulo subgloboso pallido cinerascente.—Icon. nostra Tab. V, fig. 7. Descriptio. Stipes cortici immersus, cavus, semilineam longus, ex cinereo subrufescens, intus obscurior, basi sua dilatata subepidermide sese expandit. Capitulum e ramulo prominens, ad speciem sessile, minutum, vix tertiam partem lineae diametro aequans, globosum seu compressiusculum, albido-cinereum, subpulverulentum. Microscopium compositum sporidia ostendit copiosissima aqua cito diffluentia fusiformia curvata pellucida septata, septulis circiter octo. In ramulo Alneo emortuo sparsim habitans legit in sylvula Weilensi prope Basileam Mense Aprili 1816. F. N.

The figure, a longitudinal section of the fungus and the host, shows the fungus erumpent from the bark, the latter being raised in a prominent cone, perforated at the apex. A sheet of fungus tissue, situated below the periderm and presumably surrounding the base of the cone, ascends to the apex of the latter, and emerges to form a globose pulverulent head. The head is thus sessile on the raised portion of the bark. Owing to the mode of formation of the sporodochium from a sheet of fungus tissue, a central core of cortical tissue is left in the middle of the base of the cone within the so-called stalk. Nees described the internal fungus tissue as an embedded stalk, hollow in the centre. It would appear more correct, in modern terms, to regard the sporodochium as sessile.

There is nothing in Nees' description or figure which can be considered applicable to *Microcera coccophila*, except that the conidia are fusiform and septate. The head of *Microcera coccophila* is not pulverulent, nor albido-cinereum; its stalk, when present, is not immersed, and the sessile examples, which are the usual form in Europe, are not connected with any fungus tissue within the plant on which the host insect is situated.

Consequently, unless an examination of the type specimen

proves that Nees' description and figure were chiefly products of his imagination, it is impossible to agree that *Fusarium pallens* is identical with *Microcera coccophila* Desm.

The following description of *Fusarium pallens* is given in Saccardo, *Sylloge Fungorum*, IV, p. 695:

Fusarium pallens Nees, Act. Acad. Leop. IX, pag. 237, t. V. 7; *Selenosporium pallens* Corda Icon, fung. I, pag. 7, *Fusidium obtusatum* et *pulvinatum* Link Obs. II, pag. 31, *Fusarium candidum*, Ehrenb., Sylv. 12, p. 24 (?).—Sporodochiis primo subcutaneis dein emersis, pulvinato-convexis, pallidis vel ex cinereo rufescentibus, basi dense cellulosis; hyphis repentibus complicatis; basidiis simplicibus vel parce ramulosis; ramulis fusoideis; conidiis fusoideo-falcatis, 3–5 septatis, 50 × 4·5–5, subhyalinis. *Hab.* in cortice putri ramorum Populi nigrae, Robiniae Pseudacaciae in Italia, Gallia, Arduennis, Belgio et Germania.

The literature at my disposal does not permit me to trace the origin of this description, nor the sources of the records of localities. It is probable that the specimen on *Populus nigra* was Cesati's and from Italy, and that this description is a combination of the original and details from that specimen.

Another of Wollenweber's conclusions which appears doubtful is the reference of *Fusarium coccidicola* P. Henn. to *Fusarium Detonianum* Sacc. The former was described by Hennings from specimens on a coccid on leaves of tea from East Africa. The latter was described by Saccardo from specimens on a decaying *Cyathus vernicosus* in northern Italy. Wollenweber did not examine the type of the latter, but cites a specimen on the stem of *Brassica oleracea* in his collection. As scale insect fungi, in general, are not found on other than insect hosts, this range of substrata is abnormal. *Fusarium coccidicola*, judging from the description, is most probably *Pseudomicrocera Henningsii*.

Microcera curta Sacc. is, according to Wollenweber, identical with *Fusarium larvarum* Fuck. As stated in *Trans. British Myc. Soc.* VII, p. 155, 1922, *Microcera curta* is not a *Microcera*, and it has been named several times, the earliest name then recognised being *Fusarium epicoccum* McAlp. It seems quite probable, from the description, that *Fusarium larvarum* is the same species; the latter was originally described as occurring on the chrysalides of insects, and the specimen may possibly have been on scale insects.

Under *Fusarium larvarum*, Wollenweber cites:

223.	Chrysal. et larvis insectorum	Fusarium larvarum Fuck.	Herb. Saccardo
224.	Cort. Lauri nobilis	Socia Microcera coccophila	Herb. Cesati
225.	Ram. Tiliae platyphyllae	Microcera curta Sacc.	Berlin
226.	ad fenestras sordidas	Fusarium merismoides Cda.	Berlin

The type specimen of *Fusarium larvarum* does not appear to have been examined. The specimen in Herb. Cesati is evidently one of the specimens of *Sphaerostilbe aurantiicola* collected at Florence in 1860–66, and these do contain a *Fusarium* with small strongly-curved spores which is morphologically identical with *Microcera curta* Sacc.

In the list of synonyms, *Fusarium larvarum* Fuck. is said to be synonymous with *Fusarium merismoides* Corda. The latter is the earlier name, 1838 as against 1869–70, and if the two are identical, it should presumably replace *Fusarium larvarum*. But in the list of *nomina conservanda*, Wollenweber includes both *Fusarium larvarum* and *Fusarium merismoides*. Perhaps the statement in the list of synonyms is an accidental error.

I am indebted to the Imperial Bureau of Mycology for the original description and a copy of Nees' figure of *Atractium pallens*.

ON THE IDENTITY OF RHIZOCTONIA LAMELLIFERA AND SCLEROTIUM BATATICOLA.

(With Plate XVII.)

By W. Small, M.B.E., M.A., B.Sc., Ph.D., F.L.S.

Introduction.

In a previous paper* the writer described a root disease of *Grevillea robusta*, tea, *Bixa Orellana*, *Coffea robusta* and *Casuarina equisetifolia* which was attributed to a *Rhizoctonia*. The fungus seemed to be a well-defined form confined to woody hosts and possessing characteristic sclerotia and structures which were called sclerotial plates, and it was placed in the genus *Rhizoctonia* in preference to *Sclerotium* for reasons which were thought to warrant the step and which were duly set forth. It was considered to be a new species and was named *Rhizoctonia lamellifera*. Since the original study of the supposed new *Rhizoctonia*, the writer has had an opportunity not only of investigating further occurrences of the fungus but also of studying side by side with *R. lamellifera* another sclerotium-forming fungus which was thought to be a different species because of its smaller sclerotia in nature and its lack of sclerotial plates. The latter was associated with a hot-weather wilt of French beans (*Phaseolus vulgaris* L.) and was identified as *Sclerotium bataticola* Taub., the cause of a sweet potato charcoal rot in U.S.A. An account of its occurrence has been published†. It has proved,

* Trans. Brit. Mycol. Soc. IX, p. 152 (1924).

† Kew Bulletin, 1925, 118.

however, to be indistinguishable in culture from *R. lamellifera*, and it is therefore advisable to withdraw the name *R. lamellifera* in favour of *S. bataticola*, which has a prior claim. The change of name implies the setting aside of the original reasons for preferring *Rhizoctonia* to *Sclerotium*; in other words, it means that strong likenesses between vegetative growths are considered of greater importance, at least in the meantime, than the presence of a supposed hymenophore, which was very imperfect and which has not been encountered a second time, and of clamp-connections which have proved to be very scarce.

The main purpose of this paper is to make known the change of name, and, at the same time, to record a large increase in the host range of the parasite. In the previous paper, stress was laid on the fact that the five known hosts were introduced plants. It was also remarked that the fungus was widely distributed in Uganda, and continued investigation has added weight to the truth of an observation which is in accord with what is known of the distribution of *S. bataticola* in other parts. It has been found in all the planting districts of the Protectorate except one that has not yet been searched. The list of hosts has been extended to include *Coffea arabica* L., three species of *Erythrina* (*indica* Lam., *umbrosa* H. B. and K. and *velutina* Willd.), two species of *Albizzia* (*moluccana* Miq. and *stipulata* Boiv.), cacao (*Theobroma cacao* L.), a species of *Sesbania* (probably *punctata* DC.), a garden croton (*Codiaeum* sp.), a species of *Eucalyptus* (probably *globulus* Labill.), two species of *Cupressus* (*macrocarpa* Hartn. and *Benthami* Endl.), a garden aster (*Callistephus* sp.) and a vetch from Palestine, the name of which is unknown. The *Phaseolus* already mentioned must be included, and it is probable that the rain tree (*Pithecolobium saman* Benth.) will prove to be a further host. The number of woody plants attacked is rather remarkable, for the majority of the hosts of *S. bataticola* in other countries are herbaceous. The fungus has recently been discovered on *Coffea arabica* in Kenya Colony, and there is little doubt that further investigation in these parts of Africa will reveal not only a larger area of distribution for it than is known at present but also an extended host-range. The action of the fungus on woody plants has continued to be slow. Several *Grevillea robusta* trees that are in its grip have been under the writer's observation for several years, and are dying by very gradual stages. That certain areas are infested by the *Sclerotium* is proved by its attack on more than one host in each; recently, five of the new hosts were found on a coffee estate which had already provided examples of the loss of *Grevillea* and *Bixa*. Attention may again be directed to the fact that none of the victims of the *Sclerotium* is indigenous to Uganda. The *Sesbania*

was imported from Kenya and is not, as far as the writer is aware, a native of equatorial Africa, and the other hosts were brought from further afield. The majority were destined to be ornamental plants or shade trees for coffee and cacao, and their loss is felt the more severely in that their deaths do not take place until the trees are old and large enough to fulfil their purposes.

The restriction of the attacks of the fungus to introduced plants has raised an important point with regard to infection. Cases of *Sclerotium* root disease of, for example, *Grevillea robusta* and *Albizzia moluccana* were found in districts where climatic and soil conditions were not alike, and it seemed therefore as if infection need not depend upon local circumstances. It may have been influenced to some extent by the morphological characters of the rootlets of the host plants, but the interaction between host and parasite which ultimately decided whether the former was to repel or give way to the attack of the latter is more likely to be of a physiological nature. A search for possible biochemical factors governing susceptibility to *S. bataticola* would be full of interest, and it might be expected to throw light on the apparent complete immunity of, for instance, the Para rubber tree (*Hevea brasiliensis* Müll.-Arg.) which has been introduced into Uganda and is grown in quantity in areas known to harbour the *Sclerotium*; on the partial immunity of *Coffea arabica*; or on the susceptibility of introduced *Coffea robusta* as contrasted with the immunity of the indigenous form. Cotton is a further example of an introduced plant which must have been exposed in a large measure to infection by the *Sclerotium* and which is known to be attacked by it in other parts. Besides possible physiological factors, two others may have been at work which account for its apparent immunity—the slowness of advance of the fungus and the compulsory uprooting and burning of plants after each picking season whereby the growth of Uganda cotton is really of an annual type and not perennial. To this enforced change in its mode of life and to the hygienic treatment of the field rubbish is due in great part the continued comparative scarcity of cotton diseases caused by parasitic fungi.

The present disease is an example of the bringing of hosts into contact with what is evidently a well-established parasite, the reverse of the perhaps better-known process of introducing a parasite into a new field, and it forms a parallel to another local case, that of the attack on an introduced plant, *Coffea arabica*, by the indigenous *Hemileia vastatrix* B. and Br. which occurs on native *Coffea robusta*. In the latter case, the passage of time and improvements in cultural methods seem to have

rendered *arabica* coffee more and more resistant to the attacks of *Hemileia*, but such a result can hardly be expected in the case of host plants which do not survive the attentions of the parasite. On this account, and because of the difficulty, if not the impossibility, of exterminating the fungus from large areas, the *Sclerotium* root disease is to be avoided rather than combated by direct means, a fact which has compelled coffee-planters and others to seek for shade trees among the indigenous flora which is presumably immune to the fungus.

The New Hosts.

Of the new hosts of *Sclerotium bataticola*, *Coffea arabica* is of greater economic importance than the others. It was mentioned in the course of the previous paper that the spread of *S. bataticola* from *Grevillea robusta* to *C. arabica*, the former of which is planted as shade and wind-break to the latter which is the staple crop on many European-owned estates, would have serious consequences. The same effects might be expected to follow on estates which had instituted wind-breaks of *Casuarina*. In the meantime, however, experimental attempts to infect young *Coffea arabica* plants with the fungus had failed, and, although losses of *Grevillea* and *Casuarina* trees due to the *Sclerotium* disease have continued to increase slowly, there is not yet any field evidence of the direct spread of the parasite from either of these hosts to coffee, despite the fact that diseased roots of the victims have been in intimate and prolonged contact with healthy roots of coffee. Similarly, the *Sclerotium* has had abundant natural opportunities of passing to coffee from *Albizzia* and *Sesbania*, but careful search has not revealed a single instance of infection by contact. It was supposed that a young tea plant and an arnatto affected by the *Sclerotium* had acquired the root disease through their proximity to diseased *Grevillea robusta**, but the examination of numerous examples of the new hosts of the fungus has not produced any evidence of its spread by contact. It seemed, therefore, that independent infection was the rule rather than the exception, and that the incidence of infection of woody plants was governed more by the degree of susceptibility of the host plant and the presence of the fungus than by such external conditions as control the health of the plants. The majority of the tree victims have done well for as many as five or six years before succumbing to the root disease. In herbaceous plants, again, environmental factors seemed to have a more immediate and more direct effect in determining infection and disease, for the outbreaks of *Sclerotium* disease of *Phaseolus*, asters and the Palestine vetch

* Trans. Brit. Mycol. Soc. *loc. cit.* p. 161.

occurred during hot dry spells and the collapse of the plants was rapid. The possibility of the operation of another factor, due to the existence of biological races within the species, is discussed later.

Sclerotium bataticola occurred on *Coffea arabica* in only two areas. The first instance comprised two young trees about a year old which were planted as replacements in an area in which had occurred both *Sclerotium* disease of *Grevillea* and the root disease of young tea. The fungus, therefore, was known to be present in the soil of the plantation. The diseased coffee plants, however, were not making normal healthy growth; both had been attacked by cutworms (*Agrostis* sp. or *Euxoa* sp.), and their root-systems were not only poorly developed but were handicapped by deformation of the tap-roots due to bad planting. Conditions, therefore, were favourable to the fungus, which seemed to have grasped its opportunity. In the second area, a large proportion of old trees in two plots which were bordered by a wind-break of *Casuarina equisetifolia* was in process of succumbing to the root disease. It was reported that the plots had not borne good crops, and it was only the disclosure of the presence of the *Sclerotium* on such of the sickly trees as were dug up that offered an explanation of the trouble. As several of the *Casuarina* trees in the borders of the plots had died of *Sclerotium* disease, it seemed probable that the fungus had advanced from those centres of infection into the plots of coffee. Such a supposition, however, was not supported by the facts, for affected coffee trees occurred irregularly throughout the plots and the coffee plants adjacent to the dead *Casuarina* trees were not necessarily diseased. Infection of the coffee and *Casuarina*, therefore, was to be regarded as having taken place independently, and it must be concluded that the soil of the two plots was more or less permeated by the fungus. The clearing of the land in question for the planting of coffee took place about eleven years ago, and, as there were no remains of the indigenous flora, it was impossible to attempt to trace the original source of the fungus. The roots of a dead indigenous tree in an area not far removed from the coffee plots under discussion were examined, but no trace of the *Sclerotium* was found upon them. It should be added that the land used for coffee-planting in this country was grass land rather than forest, that the dominant species in the plant association of such land was elephant grass (*Pennisetum purpureum* Schum.), and, further, that fungus root diseases of coffee have been of rare occurrence.

In the case of *Erythrina*, all three species were attacked in one large area which was originally under cacao, and, in addition,

velutina was killed in two other places. The seed of *indica* was obtained from India, and that of *umbrosa* and *velutina* from the West Indies. The cacao area had been abandoned as unprofitable, and it was only when it was cleared for the planting of coffee that the disastrous effects of the *Sclerotium* on the shade trees were fully realised. The *Erythrina* trees were in all stages of degeneration and decay. The wood of the roots was typically dry and brittle, and the disintegration of the inner cortical tissues was remarkably complete. On a certain coffee estate where *Albizzia* was extensively planted as shade, every tree of both *moluccana* and *stipulata* was either dead or dying. *Albizzia* was typical of the full effects of the loss due to *Sclerotium* disease inasmuch as the trees did not die until they were from four to six or more years of age. *Ganoderma lucidum* (Leyss.) Karst. and *Polystictus occidentalis* (Kl.) Fr. occurred, but not frequently or regularly, on dead stumps of *A. moluccana*, and *Botryodiplodia Theobromae* Pat. could be found on occasional roots. The *Sclerotium* in *A. stipulata* had progressed along a rootlet, and its advance was arrested at the junction of the rootlet with a larger root. Large exudations of gum such as were associated with the disease of *Grevillea robusta* occurred upon the stems of *Eucalyptus* trees in the grip of the *Sclerotium*. The gumming was accompanied by external blackening and cracking of the bark, and the bark and cortex of diseased roots became a dry stringy mass. The affected plant of garden croton was enabled to survive for a time by the development of young roots above the older diseased roots, a process which was aided by the piling up of soil around the base of the stem after the well-known manner of native gardeners. *Cupressus Benthami* was the only example of the death of a host of the *Sclerotium* in the nursery; young plants were attacked and killed before they were more than a few feet in height. *C. macrocarpa*, on the other hand, succumbed only as a well-grown tree.

The discovery of cacao as a host of *S. bataticola* came about more by accident than by design during the examination of a rain tree suspected of root disease. The plot in which excavation was made had been under cacao with rain tree shade. The cacao, however, was not an economic success, and it had been replaced by coffee. Cacao was extensively planted in Uganda some ten years ago, but the crop has not done well. Various hypotheses have been advanced to account for its failure, and it was thought that the discovery of the *Sclerotium* on cacao roots which had been allowed to remain in the soil when the trees were removed might throw a fresh and interesting light on the problem of its degeneration. The most characteristic field feature of the ill-health of Uganda cacao has been the die-back

of the leading shoots on which could be found at times a species of *Colletotrichum* which, in turn, was invariably succeeded by the die-back fungus, *Botryodiplodia Theobromae* Pat. The latter frequently killed to the ground first one side and then the whole of the tree, and cacao in Uganda seemed to be particularly susceptible to the advance of that common tropical fungus once it had attained a footing in a twig or branch. At the same time, root parasites were kept in mind and were looked for, but, with the exception of a few cases of root rot due to *Armillaria mellea* Fr. and one case of root disease of a few young plants due to *Helicobasidium longisporum* Wakef.*—a new species which has not been found a second time—root disease was practically non-existent; at any rate, the known disease could not be held responsible for the large and general amount of die-back. As it was possible that *S. bataticola* had been overlooked in the past, certain cacao trees in areas which were known to contain the fungus were examined. For instance, in the area which yielded examples of attack on the three species of *Erythrina*, and also contained examples of the deaths of *Albizzia moluccana* from the same cause, the fungus was found on only one cacao tree out of six examined, all of which showed advanced stages of the effects of the die-back fungus and looked as if they might be in the grip of root disease. Judged, however, by a comparison between the amount of root obtained with the *Sclerotium in situ* and the total amount of the apparently healthy roots of the same tree, or by the marked scarcity of the fungus on the six trees examined, the *Sclerotium* did not seem, from the mechanical point of view, to be deeply implicated in the loss of the trees in question. It is possible, of course, that the fungus exercised a toxic action. As cacao areas known to harbour the *Sclerotium* are not numerous, it may be impossible to carry out the complete investigation which is necessary to throw light upon the part the fungus is suspected to play, but a comparison of the amount of die-back in cacao plots which are not known to shelter the fungus with that in an area such as the above would appear to show that die-back is more prevalent where *Sclerotium* is present. Experimental inoculations with the *Sclerotium* and *Botryodiplodia Theobromae* would probably lead to an exact estimate of the harm done by each fungus, and might prove that the former was of greater significance than the latter, which is only a weak parasite. The fact remains that the proved presence of *S. bataticola* must be assumed to have been one at least of the factors to which the degeneration of cacao in Uganda has been due.

As regards the morphology of the *Sclerotium* in the tissues of its new hosts, there is little to add to what has already been

* Kew Bulletin, 1917, 310.

published. In the two young coffee plants, sclerotia were very numerous in and under the bark of the collars, and the wood of the stems at the same points was permeated by mycelium of the usual dark brown colour. No clamp-connections were found in coffee tissues. The hyphae measured up to 7μ in breadth, and were composed of cells which varied in shape and size after the typical manner of the fungus (fig. 1). The hyphae were found to pass along both wood parenchyma and fibres, but they were more plentiful in the cells of the parenchyma. Tangled masses of hyphae and extensions forming sclerotial masses were practically confined to the parenchyma cells, and, when hyphae were scarce, were not to be found in the wood fibres. Sclerotia were also numerous on the surface of the wood exposed by the cut-worm wounds which had been carried to points well above the soil by the growth of the plants. They appeared as minute black dots of the usual outlines, and measured on an average ·2 × ·15 mm. They were thus smaller than the sclerotia of the *Grevillea* fungus. In the older coffee trees, affected roots were always dry and brittle, and the absence of bark and cortical tissues in some disclosed the presence of sclerotia on the surface of the exposed wood. The sclerotia were larger than those of the young trees, and resembled in size the sclerotia of the fungus on previous hosts. They measured up to ·6 mm. in length, and were distinctly convex in shape when they protruded from their substratum. Black sclerotial plates occurred only sparingly in *Coffea arabica* roots, and no trace of a tissue resembling the supposed hymenophore described from *Grevillea robusta* was found. Fig. 2 is a drawing of a section of a sclerotial plate in the wood of a coffee root. It shows the typical shapes of the cells of the hyphae composing the plate, and it should be compared with fig. 3, which is a superficial view of a sclerotial plate occurring in the wood of a root of *Erythrina indica*. It was evident from the dried condition of the smaller coffee roots and the presence in and on them of sclerotia, and also from the fact that the mycelium of the fungus had not penetrated as far as the older roots or stems of the trees, that infection had taken place through the rootlets, a conclusion that was supported by a comparison of the condition of the roots of all the hosts of the fungus.

In *Erythrina*, the blue- or grey-black staining of the wood of affected roots due to the presence of numerous hyphae of the *Sclerotium* was remarkably clear, and the inner root cortex was frequently lined with black aggregations of hyphae resembling rhizomorphs and bearing in their course numerous small sclerotia. The supposed rhizomorphs had a structure similar to that of the sclerotial plates already described. The *Eucalyptus*

root material was remarkable for the complete disintegration of the inner cortical tissues and the large numbers of sclerotia to be found on the surface of the wood and in the cortex and bark of decaying roots. In the first position the sclerotia were free and could be easily removed on the point of a needle, and, in the last-named position, they shone, as it were, through the papery bark as groups of small black pin-heads. The sclerotia on the wood of small roots of *Eucalyptus* measured from ·06 to ·14 mm. in diameter and were spherical for the most part, while those in the cortex were larger and measured up to ·7 mm. The latter were also spherical and often protruded from the surface of the inner cortex. *Sesbania* root material resembled that of *Eucalyptus* in the large numbers and sizes of the sclerotia to be found in the cortical tissues, and in *Albizzia* material masses of sclerotia could be found in the bark and cortex of small roots. On the herbaceous hosts, the sclerotia were, on the whole, smaller and more regularly spherical than those of a woody substratum, and sclerotial plates were absent. The sclerotia of *Phaseolus* were of an average diameter of ·1 mm., and of aster and the Palestine vetch ·08 mm. There was considerable variation in both size and shape of the sclerotia of *S. bataticola* from the different hosts, but all were alike in colour, in structure and in oily content. The smaller sclerotia of herbaceous plants were paralleled by those of woody hosts like *Eucalyptus*, and the internal hyphae of all the hosts were strongly alike, especially in the woody plants, but the main morphological proofs of identity between a form that was named as a new species and was thought to be confined to woody hosts and *S. bataticola*, as it occurred on the herbaceous plants, were obtained by cultural studies of the various strains.

In the original account of *Rhizoctonia lamellifera*, certain anatomical characters and certain indications of the presence of the fungus, for example, the structure of sclerotia and sclerotial plates and the dryness and brittleness produced in affected roots, were emphasised as distinctive and diagnostic. The continued examination of infected material, particularly that of woody plants, has only served to throw those points into greater prominence, but it is necessary to add to them one other, viz. that infection had taken place independently and not by contact, a point on which the field evidence was very striking and clear.

New Strains of *Sclerotium bataticola* in Culture.

In the course of many attempts to isolate the *Sclerotium* from its new hosts, it was found that large fragments of root tissue of woody plants gave better results than small pieces. They

could be sterilised more easily, and it was an advantage to be able to pare them if and when contaminations appeared. Growths from fragments were obtained on filter paper moistened with 5–10 per cent. cane-sugar solution and in 1 per cent. agar in water. The latter medium was unfavourable to the growth of bacteria which were frequently difficult to avoid, even after careful surface-sterilisation of the material, and it was used in quantity in Petri dishes. The commoner contaminating fungi (a species of *Alternaria*, a Moniliaceous form and a *Fusarium*) preferred to grow on the surface of the medium, and, if the *Sclerotium* had begun growth in the medium, its hyphae could be cleanly and easily removed by first turning over blocks of the medium containing them. Hyphae growing upon filter paper were found at times difficult to transfer to another medium, but the difficulty could be overcome by allowing the culture to dry up and in that way inducing the production of the structures called cell-formations, which were comparatively large in size and irregular in outline and so could be easily picked up. Chlamydospores were obtained and utilised in the same way. The number of fragments of woody plants, however, from which the fungus was induced to grow, was remarkably small, and the writer has concluded that the hyphae in the tissues were not only short-lived but also sensitive to sterilising agents applied both with and without heat. The penetration of the latter was no doubt assisted by the organic changes brought about by the fungus in the wood and cortex of diseased roots, but, nevertheless, tissue fragments tested for growth without sterilisation proved to be barren in the majority of cases. On the other hand, there was no difficulty in isolating the fungus from herbaceous plants.

It was made clear in the previous account of *R. lamellifera* that neither fresh nor rested sclerotia had been induced to germinate, and it now falls to be recorded that growths of hyphae were obtained from sclerotia from three woody hosts of the fungus, *Coffea arabica*, *Eucalyptus* and *Sesbania*. In all three cases, the sclerotia could be readily detached from their substrata, and they were apparently in a more completely rested state than the sclerotia used in previous attempts. When placed on filter paper moistened with cane-sugar solution, the sclerotia from *Eucalyptus* and *Sesbania* germinated at once, and it was a simple matter to obtain single-sclerotium isolations from these hosts. The sclerotia from *Coffea arabica* gave no growth on the same medium, but germinated when glucose-lemco agar was poured over them. At the same time, coffee sclerotia placed directly in glucose-lemco agar germinated at once. In the three strains, the initial mycelial growth resulting

from the transfer of hyphae derived from sclerotia resembled closely that described in the previous paper. In twenty-four hours, the area occupied by the fungus around the points of inoculation was a circle of about 2 cm. in diameter which contained hyphae varying from 2 to 12 μ in thickness and from 25 to 50 μ in length of cells, and in three days a vigorous aerial growth of mycelium reached the upper glass of a Petri dish. Sclerotial formation followed in the medium in about seven days. The first sclerotia appeared on the larger and older hyphae. Fig. 4 shows the stage of sclerotial formation reached in a glucose-lemco agar culture of the *Coffea arabica* strain in twelve days. The young sclerotial norm in culture was more or less spherical in shape and 60–65 μ in diameter, and the irregular outlines of the majority of the sclerotia were due to what may be called extra growth which could be controlled to a certain extent by varying the moisture content of the medium. The hyphae of *S. bataticola* in certain media, and especially on potato plugs, became so dark and apparently pressed together that they simulated the formation of a sclerotial plate, but the latter never became prominent or persistent. The hyphae, moreover, were not noted to develop the typical morphology of the hyphae of a natural plate. When the sclerotia were mature, the hyphae in glucose-lemco agar cultures seemed to lose their contents and dark colour and eventually to disappear. When small agar blocks with mycelium and sclerotia were removed from cultures and placed for observation in Petri dishes or hanging-drop chambers, the growth of the hyphae continued on the glass and took a more tangled and wavy form than in ordinary circumstances. Sclerotial formation also continued, and young sclerotia developed under such conditions were more regularly globose and smaller (about 45 μ in diameter) than those produced in the nutritious medium. Cell-formations and chlamydospores were both formed. The former appeared to be a middle course between the formation of sclerotia and the development of simple chlamydospores, and the latter were formed in both chains and groups. Isolations of the *Sclerotium* from *Albizzia stipulata* were obtained from small fibrous roots containing hyphae and sclerotia, but direct growth from the sclerotia was not observed. In addition to the cultures obtained from the sclerotia of *Coffea arabica*, *Eucalyptus* and *Sesbania*, isolations were made from root fragments of each. It was noted that, in each of these four strains, the early period of intense and rapid development of sclerotia in culture was followed by the appearance on the surface of the medium of numerous tufts of hyphae, which were hyaline but grey-white in the mass and composed of comparatively thin-walled cells containing much oil and

resembling in shape the elements of sclerotial plates. At the same time, the surface of the medium became furrowed and wrinkled as if it were drying up. Fig. 5 shows the appearance of the hyphae in question. When a single hypha from a tuft was transferred to fresh medium, the resulting growth did not differ in any way from that of the isolations obtained by other methods, and sclerotial formation took place in the usual time and manner. Cell-formations and chlamydospores were found only in filter paper cultures and in growth on glass, and it seemed that their place was taken in the case of a solid medium by the hyphae under discussion. It may be added that the latter became dark with age.

Cultures of the various strains of *S. bataticola* isolated from both woody and herbaceous hosts were therefore obtained at different times from tissue fragments containing hyphae, from sclerotial plate tissue, from sclerotia, from pieces of the supposed hymenophore, from cell-formations and chlamydospores formed artificially and from the hyphae just mentioned, and in all cases they developed along identical lines. Successive parallel cultures of the new strains begun from a single sclerotium of each were set up on various media, the most frequently used of which were glucose-lemco agar and Dox's agar. Although there seemed to be slight differences in the initial vigour of the mycelial growth of the various strains on the same medium, it was found that the development of each, measured by the time and rate of formation of sclerotia, was alike, that no one of the strains was morphologically distinguishable from the others, and, further, that sub-culturing led to no apparent diminution in the vigour of mycelial growth and sclerotial formation. The Dox agar medium was made by adding $2\frac{1}{2}$ per cent. agar powder to Dox's solution, and it proved to be very suitable for the growth of *S. bataticola*.

In the previous account of this fungus, it was pointed out that the connection between sclerotial plates and sclerotia was established in cultures started from the plates, and that the converse relation between sclerotia and sclerotial plates had not been proved by experiment. In the media employed, only the pretence at sclerotial plate formation already mentioned was observed. The effort to form a plate, however, appeared to be distinct and worthy of encouragement, and experiments were therefore made with a more natural substratum of growth. Sclerotia and hyphae of the *Coffea arabica* strain were sown on sterilised wood blocks of *C. arabica* and *Grevillea robusta* which were kept in flasks. Growth of the fungus on the blocks was rapid and profuse, and small sclerotia of 60μ diameter increasing after ten days to 90μ were formed in great numbers.

The external growth on coffee wood was more profuse than that on *Grevillea*, and the depth of penetration of the former by the fungus was ·07 mm. in seven days. At the same time, the internal hyphae were forming flattened lens-shaped extensions which resembled the beginnings of sclerotia or sclerotial plates. After fourteen days penetration was found to have increased, and the hyphae of the fungus were seen to resemble in habit and morphology those found in nature. They had grown freely along medullary ray tissue and had filled the cells with hyphal extensions recalling sclerotial plate tissue. When some of the blocks were transferred from a moist to a dry atmosphere in a desiccator, it was noticed that the fungus developed the grey-white tufts of mycelium already described and figured. After six months, a proportion of the blocks was split open and examined. In both *Coffea* and *Grevillea* wood, penetration was so complete that the dark hyphae of the fungus could be followed with the naked eye. Sclerotial formation was plainly visible, but, although the hyphal extensions mentioned above were larger and more numerous than formerly, sclerotial plate formation resembling that occurring in nature could not be said to have taken place. A similar examination having similar results was made after twelve months. It is worthy of remark that the penetration of the fungus, judged by the extent of the formation of sclerotia and masses of hyphae, was eventually more thorough in *Grevillea* wood than in that of *Coffea arabica*. This result seemed to depend upon differences in structure and texture of the woods, and it agreed in its implications with the state of affairs in the field where *Grevillea robusta* has been much more susceptible to *Sclerotium* disease than has *Coffea arabica*. Although experimental proof of the connection between sclerotia and sclerotial plates was not obtained, there was no doubt that both structures belonged to the species *S. bataticola*. Typical hyphae and sclerotia were derived from fragments of the plates, and the morphology of the plates was not only *Sclerotium*-like to a strong degree but also constant and consistent.

The supposed hymenophore which was described in the previous paper occurred in association with a sclerotial plate growing over the wood of a diseased *Grevillea robusta* root, and it is the opinion of the writer that the fundamental function of the plates, if they possess any function at all, is concerned with the formation of a hymenophore. At the same time, all attempts to induce the formation of a hymenophore on the sclerotial plates of many of the woody hosts of *S. bataticola* by keeping root fragments in a moist atmosphere or in moist sand for a long period have failed. The discovery of the perfect stage of the fungus would lead to its removal from the genus *Sclerotium*,

and the presence of clamp-connections seems to point in a certain definite direction, while the fact that clamp-connections are very scarce in both nature and culture may be correlated with the theory advanced in the former paper that the scarcity and imperfect nature of the supposed hymenophore are the result of a gradual loss of function. However that may be and whatever perfect stage the fungus may prove to possess, the morphological resemblances between the vegetative growths of the strains in culture were so exact and consistent that there was good reason for identifying them all, temporarily at least, as *S. bataticola* and for ruling out any suggestion of the presence of more than one species among them.

Each of the seven new strains of the fungus was grown in mixed Petri dish cultures with itself and with the other six strains. It was found that, while the approach to each other of the growths in the halves of the dish gradually narrowed the no-man's land between them until it became a mere line, no real coalescence took place except in the case of strains grown with themselves. No *Corticium* or other stage of the fungus was found in any of the mixed cultures. At the same time, it was noted that certain strains consistently caused a prune agar medium to become black, while others left it transparent. The darkening of the medium was accompanied by a greater development of aerial mycelium. When further media were employed with a view to showing whether these growth characteristics were permanent or not, it was found that they varied with the media and that they could not be regarded as the expression of qualities inherent in the different strains.

Inoculation Experiments.

Inoculation and cross-inoculation experiments with strains of *S. bataticola* from *Coffea arabica, Sesbania, Eucalyptus* and *Albizzia stipulata* were attempted by two methods. In one, the fungus was introduced in large quantities into sterilised soil in tins in which plants were grown from seed, and, in the other, fungus and intended host seedlings were grown together in large tubes containing Richard's solution diluted from 1000 c.c. to 1500 c.c. by the addition of sterile distilled water. The host plants employed were *Coffea arabica, Albizzia moluccana* and *Eucalyptus globulus* and, as natural infection was desired, care was taken not to break or wound the roots of the plants used in the second method. By the soil method, infection of a single *Eucalyptus* seedling by the *Coffea arabica* strain was the only result attained. The remaining plants grew well, and were not infected after five months' growth. In the tube experiments, the fungus was shown to grow well in Richard's solution before

the seedlings were introduced, but the majority of the tubes became contaminated despite careful surface-sterilisation of the seedlings and many of the seedlings did not flourish. The *Sesbania*, *Albizzia stipulata* and *Eucalyptus* strains were induced to infect only *Coffea arabica* seedlings; positive results were therefore few, and no direct-inoculation results were obtained. Attempts were also made to infect cotton seedlings with the above strains of *S. bataticola*, but neither method yielded successful results. What little positive evidence was obtained from the experiments was against the existence of biological races in the fungus, despite the evidence from the field, where, for example, the *Grevillea robusta* or *Sesbania* or *Albizzia* strain appeared to be unable to infect coffee. Cross-infection in the field was determined by the interaction of host, parasite and environmental groups of factors, and the lack of cross-infection between, for example, *Grevillea* and coffee, was explicable on the ground that coffee was more resistant than *Grevillea* to the invasion of a fungus to which the trees were equally exposed. Again, the fungus need not have been at any given time at the stage of development that enabled it to infect directly or to pass easily from one host to another, and the difficulty of obtaining growths of it from diseased roots, especially those which had become dry and brittle, pointed to its being in a state of activity only in the region of its advance. Further, each strain of *S. bataticola* might be and apparently was a morphological entity, but it did not follow that it was at the same time a physiological entity in the sense that it was always capable of a certain, say, parasitic, behaviour. When due consideration was given to all the aspects of infection, the factors of greatest weight in determining field infection of either kind seemed to be, in the majority of cases, the presence of the fungus and the susceptibility of the host plant.

During the investigation of the hot-weather wilt of beans due to *S. bataticola*, which has already been referred to, the behaviour of four strains of the fungus (from Uganda beans, from India, from cotton in Egypt and from U.S.A. sweet potato charcoal rot) towards wounded and unwounded sweet potatoes was shown to be alike. Neither of the strains could penetrate the unbroken skin of the sweet potato, and all four, when provided with a wound entrance to the tissue of the tuber, caused a charcoal rot which corresponded with the original charcoal rot described by Taubenhaus. Similar experiments were made with the later strains of *S. bataticola*. The four woody plant strains (*Coffea arabica*, *Eucalyptus*, *Sesbania* and *Albizzia stipulata*) were employed at first, and it was found that none of them caused the charcoal rot even with a wound entrance. The results

were unexpected, and the same potato was therefore tested with the original four strains mentioned above. It was again found that none of the strains caused the charcoal rot. The particular potato used in these trials, a hard brown-skinned one, was probably resistant to *S. bataticola* as a rot-producing agent, but it should be noted that the inoculum used was drawn in all eight cases from old cultures. A further experiment consisted of a similar test of a hard pink-skinned sweet potato in which the inoculum was drawn from young fresh cultures of the old and the new strains along with that derived from the Palestine vetch, a total of nine. All nine strains behaved with remarkable unanimity, for all caused typical charcoal rot in from sixty to eighty days. Apart from the question of the comparative susceptibility of the two types of potato, the difference in the behaviour of the old and the young inocula is usually expressed by saying that the strains in culture lose with age their ability to cause infection. They may thus be presumed to be genetically unstable, but modern research bears against such a view. The paucity of experimental results, the state of affairs in the field where, for example, it was difficult to postulate the existence of as many as seven biological races in one small area like that mentioned at the beginning of this paper and the apparent loss of the power of parasitism point rather to the existence of discrete physiological strains within any one isolation of *S. bataticola*.

Summary.

1. A parasitic fungus which was described as a new species under the name *Rhizoctonia lamellifera* mihi is now regarded as identical with *Sclerotium bataticola* Taub. and reasons for abandoning the former of these names are given.

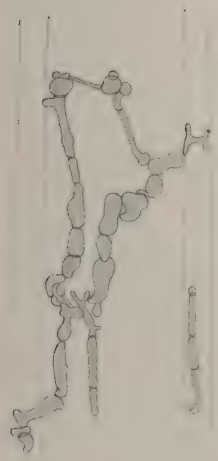
2. An extension of the host range of the fungus with particular reference to woody plants is reported.

3. Sclerotia from the tissue of woody hosts have now been germinated, but the sclerotial plates characteristic of the fungus in the roots of woody plants have not been obtained in culture, nor has the supposed hymenophore been found a second time.

4. Inoculation and cross-inoculation experiments have given only a few results. In the majority of cases, infection in the field seems to depend more upon the susceptibility of the host plant and the presence of the fungus than upon the factors which control environmental conditions.

EXPLANATION OF PLATE XVII.

Fig. 1. Hyphae in root of *Coffea arabica*. × 500.
Fig. 2. Sclerotial plate in wood of *Coffea arabica* root. × 500.
Fig. 3. Sclerotial plate in root of *Erythrina indica*. × 500.
Fig. 4. Sclerotia in culture of *Coffea arabica* strain. × 82.
Fig. 5. Hyphae from surface of medium. × 500.



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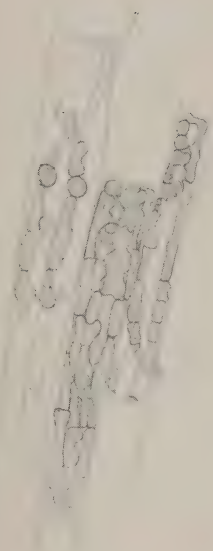

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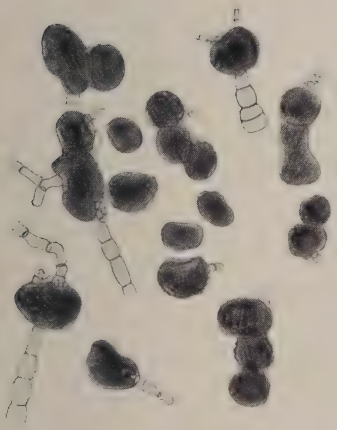

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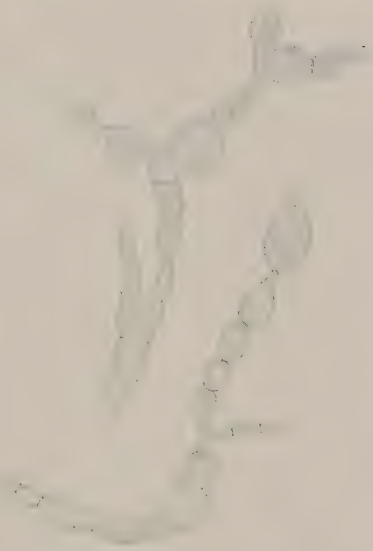

5

SCLEROTIUM BATATICOLA

ON THE OCCURRENCE IN BRITAIN OF THE CONIDIAL STAGE OF SCLEROTINIA CYDONIAE SCHELL.

(With Plate XVIII.)

By H. Wormald.

Horticultural Research Station, East Malling, Kent.

In 1920 the present writer (11) recorded the occurrence in this country of the conidial stage of *Sclerotinia Mespili* Schell. This fungus was found causing dark brown, almost black, blotches on medlar leaves (*Mespilus germanica* L.), the infected areas eventually producing conidial fructifications of the *Monilia* type. A characteristic feature of the conidia was the presence of fusoid bodies known as "disjunctors*" which developed between, and separated, the spores in the chain. Later (12), an apothecial form developed from mummified flowers collected from underneath trees infected with the leaf blotch, and this form conformed with Schellenberg's description of the ascigerous stage of *Sclerotinia Mespili.*

On the Continent a closely related fungus is known to occur on the quince (*Cydonia vulgaris* Pers.) and, after the discovery of the medlar fungus, a search was made for the one parasitic on quince trees, but without success until the present year. An examination was made of a row of quince trees at the East Malling Research Station early in May, 1925, when a few leaves on several trees were found with blackened blotches similar to those previously seen on medlar trees, and it was suspected therefore that the quince leaves were infected by *S. Cydoniae.* On placing such leaves in a moist chamber spore masses developed in a few days and about the same time conidial fructifications were also found on diseased leaves on the trees. The conidia grew in moniliform chains and, like those of *S. Mespili*, were provided with disjunctors. These conidia were smaller and less spherical than those of the medlar fungus, but it was evident from the nature of the infection and the morphology of the parasite that the fungus was closely related to *S. Mespili* and that it was therefore probably Schellenberg's *S. Cydoniae.*

The fungus causing these symptoms on quince leaves has been known on the Continent since 1888 when Briosi and Cavara (2) gave the name *Ovularia necans* to a fungus said to occur on the medlar and the quince. In 1892 Prillieux (6)

* The structure and development of disjunctors has been described by Woronin (13) in his paper on *Sclerotinia Vaccinii.*

described the quince disease and referred the parasite to *Monilia Linhartiana* Sacc., a fungus found by Linhart on *Prunus Padus*; in the following year Prillieux and Delacroix (7) found the ascigerous stage and named it *Ciboria* (*Stromatinia*) *Linhartiana*. Woronin (14) in 1895 showed that *Monilia Linhartiana* Sacc. was the conidial stage of his *Sclerotinia Padi*.

Schellenberg (8) found that the quince fungus was distinct from that occurring on *Prunus Padus*, and therefore suggested the name *Sclerotinia Cydoniae* for it; he also found (9) that it was distinct from that found on the medlar. In a recent paper (10) he maintains the distinction between these fungi biologically as well as morphologically, for he finds by inoculation experiments that *S. Cydoniae* and *S. Mespili* are confined each to its own particular host. Berkhout (1), however, records the occurrence of *S. Cydoniae* on both quince and medlar in Holland*.

Sclerotinia Cydoniae, under that name or as *S. Linhartiana*, has been found in various localities on the Continent; in addition to the authors mentioned above, Pieper (5), Osterwalder (4) and Naidenov (3) record it.

As *Sclerotinia Cydoniae* appears to be hitherto unrecorded for Britain, a brief description of observations made at East Malling may be of interest to workers in this country. On the diseased leaves examined, only one infected area was seen on each leaf (fig. 1), but eventually the infected portion extended over the whole leaf which became brown and withered. Sometimes the infection extended from the lamina along the petiole and into the axis of the shoot so that the whole shoot wilted. The conidia were produced on the upper surface of infected leaves in grey tufts which, however, soon became more or less confluent to form an almost continuous layer. The conidial fructifications were at first limited to the regions bordering on the midrib and the main veins (fig. 2), but later they became more generally distributed.

Infected leaves emitted an aromatic odour which was very noticeable on removing the lid of a large Petri dish which served as a moist chamber in which diseased leaves had been kept for a day or two. A similar odour is given off by medlar leaves infected with *S. Mespili*. Woronin (13) in 1888 described the leaves of the Cowberry (*Vaccinium Vitis-Idaea* L.) infected with *Sclerotinia Vaccinii* as giving off "einen angenehmen, mehr oder minder intensiven Mandelgeruch," and stated that insects were attracted by the odour to the infected leaves and carried the conidia of the fungus to the stigmas of the flowers,

* The writer had the opportunity of examining a medlar leaf sent by Miss Berkhout and found that the dimensions of the conidia were of the same order as those of *S. Cydoniae* (see below, p. 305).

which in turn became infected. Schellenberg suggests that the odour emitted from infected medlar and quince leaves has a similar function.

The two fungi found on quince leaves and medlar leaves are obviously closely related. There is a marked difference, however, in the size of the conidia of *S. Mespili* and *S. Cydoniae*. Schellenberg (9) gives the dimensions of the conidia of *S. Mespili* as 15×18–$20\,\mu$; the writer (11) found them to be $10{\cdot}5 \times 12$–$20{\cdot}5 \times 25\,\mu$ (mostly 16–20×18–$22\,\mu$, with an average of $17{\cdot}1 \times 19{\cdot}3\,\mu$). Schellenberg's figures (8) for the conidia of *S. Cydoniae* are $7 \times 12\,\mu$, while the fungus at East Malling was found to have conidia rather larger, the range of size being 9–14×10–21, the great majority (about 90 per cent.) coming within the limits 9–12×11–$15\,\mu$, the average size of a hundred conidia being $10{\cdot}5 \times 13{\cdot}1\,\mu$.

About the same time that the fungus was discovered at East Malling, Mr W. J. Dowson found a similar fungus on quince leaves at Wisley. Mr Dowson kindly supplied specimens for comparison, and the fungus was found to be identical with that found at East Malling, the majority of the conidia again coming within the range 9–12×11–$15\,\mu$.

Whether the divergence, shown above, from Schellenberg's figure is a specific one or due merely to environmental factors will probably not be ascertained until the ascigerous stage is found in this country, but in view of the degree of specialisation found by Schellenberg (10) in these Sclerotinias the fungus on quince leaves which has been found at East Malling and at Wisley must be referred at present to *Sclerotinia Cydoniae*.

Berkhout (1) gives the dimensions of the conidia of *S. Cydoniae* as 10–11×11–$12\,\mu$, and measurements, made by the writer, of conidia from a medlar leaf (sent by Miss Berkhout in 1922) infected presumably by *S. Cydoniae* (see above, p. 304) were found to be $5{\cdot}5$–$12{\cdot}5 \times 6{\cdot}5$–$15\,\mu$ with an average (100 conidia) of $8{\cdot}5 \times 10\,\mu$. These figures are nearer to those given by Schellenberg.

The fungus has been isolated and grown in pure culture but detailed cultural studies have not yet been made. Like *S. Mespili* it grows very slowly on prune juice agar and on sterilised potato; on prune juice agar it produces numerous pustules of "microconidia," but no macroconidia.

The writer desires to express his indebtedness to Miss E. M. Wakefield for notes on the earlier papers referring to the quince disease, to Miss C. H. Berkhout of the Centralbureau voor Schimmelcultures, Baarn, Holland, for sending specimens from Holland, and to Mr W. J. Dowson for supplying infected quince leaves from Wisley.

Summary.

1. The occurrence of the conidial stage of *Sclerotinia Cydoniae* Schell. on quince leaves at East Malling, Kent, and at Wisley, Surrey, is recorded.

2. The dimensions of the conidia were found to be rather greater than those given by Schellenberg.

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DESCRIPTION OF PLATE XVIII.

Fig. 1. Blotch on quince leaf caused by *Sclerotinia Cydoniae*.

Fig. 2 Infected quince shoot with wilting leaves. The conidial fructifications are seen as a whitish layer along the midrib and main veins.

1

2

SCLEROTINIA CYDONIAE

ON SOME FEATURES OF GROWTH AND REPRODUCTION IN SPORODINIA GRANDIS LINK.

(With 2 Text-figs.)

By Wilfrid Robinson, D.Sc.

THE work of Klebs (4, 5) on the connection between external conditions and the appearance of reproductive structures in fungi served to establish the fact of an antithesis between vegetative growth and reproductive activity. He found that differing external conditions led to vegetative growth, to the development of asexual or sexual reproductive structures. Klebs also pointed out that the external conditions operate upon the organism by inducing internal changes which find expression in the form of the reproductive structures. In many of the cases he studied the excess of organic compounds was thought to favour the appearance of sexual organs while an excess of nitrogen compounds favoured vegetative growth.

In the work of Klebs, and also in that of later investigators on similar lines, so far as I am aware, the nature of the internal changes occurring has not been precisely determined for any given fungus. The determination of such internal changes is obviously a matter of great difficulty, but in the course of an attempt to analyse experimentally some of these internal changes in *Pyronema confluens* (7) methods were tried which have given even more striking preliminary results with *Sporodinia*.

Sporodinia grandis Link*, as is well known, occurs in nature on the fruit-bodies of decaying agarics, and other higher Basidiomycetes. It grows readily, however, on culture media rich in sugars. The material used in this investigation was isolated and grown on malt-extract agar from a growth of the fungus found on a decaying sporophore of *Boletus*. *Sporodinia* is a characteristic member of the Mucorineae, possessing two types of reproductive structure, sporangia and zygospores.

In plate cultures on a suitable nutrient agar it grows for the most part superficially, spreading rapidly to the margin of the dish. When this margin is reached the fungus gives rise to aerial branches which then, according to the conditions of culture, produce sporangia or zygospores.

Klebs showed that on a good nutritive medium with a moderate supply of nitrogen and an abundance of sugar,

* It would appear (see *Journ. Bot.* LIII (1925), p. 303) that *Syzygites megalocarpus* (Ehrenb.) Fr. is the strictly legal name for this fungus, but as the name *Sporodinia grandis* Link is almost invariably used in recent physiological investigations it is adopted here.

sporangia were developed most readily in an atmosphere of 75–80 per cent. relative humidity and at humidities of from 90 to 100 per cent. only zygospores were produced. He regarded the transpiration of the fungus as the factor which determined whether zygospores or sporangia should be produced and he also demonstrated that carbohydrates and higher alcohols were specifically favourable to zygote production. Transpiration, or its relative rate, was regarded by Klebs as a stimulus which was active in liberating the morphogenic processes in reproduction. Minimal transpiration, according to this view, favoured zygote production, while a more active transpiration led to the development of sporangiophores. The aerial branch-systems which give rise to zygotes or sporangia were regarded by Klebs as morphologically homologous structures.

Brefeld (1), and more particularly his pupil Falck (2), worked on the relation of *Sporodinia* to external conditions and diverged from most of Kleb's (4) conclusions. Falck produced experimental evidence that the concentration of the medium is the dominating factor determining whether zygospores or sporangia shall arise. Neither Brefeld nor Falck, however, made due allowance for the possible effects of humidity, and on this account Klebs (5) regards many of their results as confirmatory of his conclusions.

In the present work, with the strain of the fungus used, it was generally possible, by following the methods described by Klebs to produce either type of reproductive structure at will. It should, however, be stated that prolonged culture, involving several transfers on an unfavourable medium, has been found to lead to a gradual diminution in the power of producing zygospores. Whilst the results obtained by Klebs have been repeated, the loss of reproductive vigour after prolonged culture may explain the divergence between the results of Klebs and Brefeld and Falck*.

Having found in *Pyronema confluens* (7) definite relations existing between growth activity and reproduction, tests were carried out to ascertain whether any such relations held in *Sporodinia*.

Methods.

For culture a liquid medium containing either 5 per cent. or 10 per cent. of malt extract was used. In each culture 25 c.c. of medium, contained in a 250 c.c. conical flask, was inoculated with a loopful of a suspension of spores.

Using series of such cultures the relations between the vegetative growth, the respiratory activity and the development

* Klebs (1902) has pointed out important differences in the strains of *Sporodinia* used by Brefeld and himself respectively

were studied under appropriate conditions. In the case of sporangial development, for instance, a series of 50 flasks was inoculated and incubated at 22° C. for two days. At the end of this time a vigorous growth of submerged mycelium had taken place in all the cultures. Ten of the cultures were then in turn attached to an apparatus for measuring the rate of respiration as given by CO_2 output, by the method employed by Osterhout (6) and his collaborators. This rate having been obtained the mycelial mat was, in each case, removed, washed five times with cold water on the filter paper and dried to constant weight at 60° C. The average weight of these ten mycelial mats was taken as a figure for one of the points on an average growth curve. The following day the same procedure was repeated for ten more cultures of the series. By this time, that is, on the third day of growth, the mycelium had produced a fine aerial felt over the whole surface of the culture. The mycelial mats were washed and dried as before and the average weight gave the second point on the growth curve. The same process was repeated on the fourth, sixth and tenth days, five points being thus obtained for the average growth curve of the series of cultures. The condition of the cultures was carefully noted each day so that the rate of respiration and of growth might if possible be correlated with morphological changes in the fungus. On the fifth day the first signs of sporangiophores were detected in more than half the cultures remaining.

The respiratory activity was calculated in terms of the volume of CO_2 per gram of mycelium per minute. This method is not an altogether satisfactory basis for estimating the respiratory activity of fungal cultures since with increasing age of the cultures there are increasing amounts of inert non-respiring matter in the cell walls and cell contents. It, however, was the best available under the conditions of the experiments. Further, the results cannot be seriously misleading on this account, since there was no doubt from the measurements that the absolute amounts of CO_2 liberated by a culture fall off with development.

Kidd, West and Briggs (3) have found that the "respiratory index" of the flowering plant *Helianthus annuus* shows similar falling off with age.

An average growth curve obtained by plotting the average weights against time is given in fig. 1. On the same figure is given a curve representing the respiratory activity obtained by plotting volume of CO_2 per gram of mycelium per minute against time. The condition of the culture in regard to the state of development of the sporangia is indicated on the same diagram. It is seen that the respiratory activity falls off from a high rate in the early stages of growth to a very low rate on the later days.

The growth curve, at first steep, gradually falls off from the fourth day and after the seventh day becomes negative owing to the autolysis of the fungal mat having set in.

The morphological development of the fungus showed marked correlation with these curves. On the fourth day, when the growth curve was beginning to flatten and the respiratory rate to fall off, the aerial hyphae which were the forerunners of the sporangia made their appearance. By the sixth day the sporangia were maturing, the growth curve had become flat and respiration had fallen to a very low rate. Presumably the

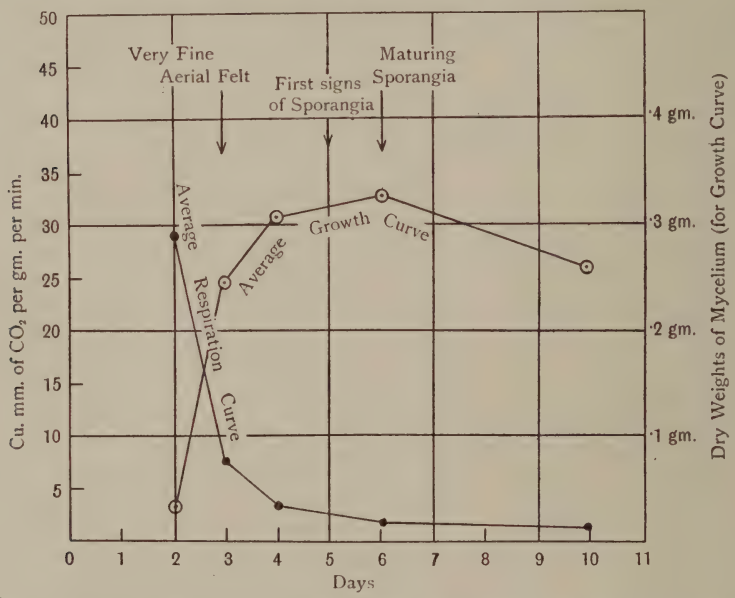

Fig. 1. Curves showing the average growth and average output of CO_2 due to respiration in cultures of *Sporodinia* grown under conditions favouring the development of sporangia.

medium was by this time becoming relatively exhausted. This question was not tested in the present series of experiments. It must be emphasised in regard to the results given in fig. 1 that no aerial hyphae made their appearance until the growth curve had begun to flatten and that the further falling off in the growth rate was accompanied by the appearance and subsequent development of the sporangia. The maturation of the latter was attended by an actual loss in dry weight owing to the respiration of the fungus on the exhausted medium.

The question might be raised as to whether the relations just described are not merely correlation effects dependent on the

development of the sporangia. In other words there is the possibility that the morphological changes associated with reproduction lead to the falling off in growth rate as measured by the increase in dry weight. That this is not so is indicated by the fact that no sign of reproductive structures has ever been seen in this work until the growth rate has begun to fall off. The nutritional factors involved in the slowing of the growth rate appear to be responsible for the internal changes which reach morphological expression during the development of sporangia. If the conditions of culture are so arranged that there is no falling off in the growth rate then no reproductive structures arise and little aerial mycelium is produced.

Zygospore Formation.

The corresponding relations to those described above were studied in similar series of flask cultures, which were given the appropriate conditions for zygospore formation. The cultures were grown at the ordinary temperature of the laboratory (*i.e.* about 15° C.) and the flasks were corked above the plugs in order to obtain the high humidity necessary for zygospore formation. Before making the estimations of the rates of respiration the accumulated CO_2 of the previous period of respiration was thoroughly flushed out by passing a stream of air through the flasks. The methods used were similar to those described above for the sporangial series, though the number of cultures was smaller.

The curves shown in fig. 2 give the general trend of the results. As before there is a falling off in the growth rate as measured by the dry weight of mycelium formed in a given time. This falling off in growth is accompanied, as before, by the appearance of aerial hyphae, but under the relatively more humid conditions some of these hyphae subsequently become zygosporic branch-systems. The growth rate continues to be reduced as zygospores appear, and finally during the maturation of the zygospores there is a net loss in weight due to the loss by respiration being greater than the intake of materials from the now exhausted medium. As in the case of the development of sporangia the rate of respiration*, as measured by the output of CO_2, has fallen to a low level before reproduction is initiated.

From the results given it appears that in the initiation of both types of reproductive structures in *Sporodinia* similar factors are at work. In both cases the reproductive bodies are, as Klebs pointed out, aerial structures arising on hyphal branches which grow away from the medium. It seems clear that the tendency

* In this case the respiration curves from three cultures of the series are given in place of the average respiration curve in fig. 1.

for the development of the aerial hyphae is the first visible expression of the reduction in the growth rate consequent on the exhaustion of the medium in nutrient materials. Whether the reproductive structures which then arise on these aerial hyphae are sporangia or zygospores depends on other factors of which, as Klebs has shown, the most important are the rate at which water is lost from the hyphae and the initial carbohydrate and nitrogen concentration of the medium. It must be noted, however, that even after the appearance of the aerial hyphae the conditions may inhibit the development of either type of reproductive structure. Considerable acidity in the medium or high temperatures have such inhibitory effects.

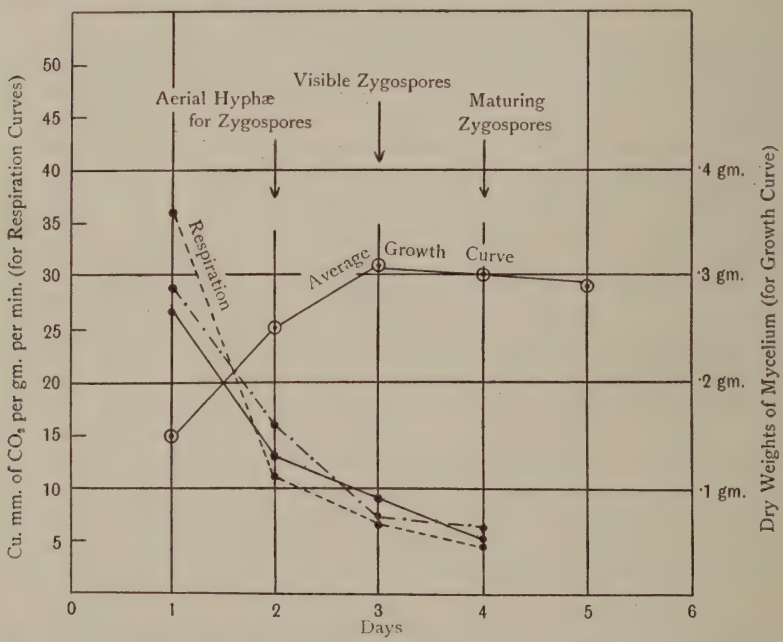

Fig. 2. Curves showing the average growth and the output of CO_2 due to respiration in cultures of *Sporodinia* grown under conditions favouring the development of zygospores.

In the further development of the aerial branch-systems into sporangiophores on the one hand, and zygosporic tufts on the other, important differences in the structure and contents of the hyphae soon become manifest. In the development of the sporangia the erect aerial hyphae are at first colourless and show considerable growth. The tips then begin to branch dichotomously and finally the young sporangia swell out and are cut off by septa. The pressure from below on the septum leads to

the bulging of the columella into each sporangium. Vacuolation takes place in the hyphae below the sporangia and transverse septa appear in the branches and main axis of the sporangiophore. Finally, as the spores are maturing within the sporangia, the sporangiophore becomes somewhat brown in colour owing to the deposition of a dark substance in the hyphal walls.

In the production of the zygosporic branches the aerial hyphae do not grow nearly as tall as in the case of the sporangial branches. The dichotomies are less frequent, the hyphae grow further after branching and taper at their extremities. The hyphae are more densely filled with protoplasmic contents than in the hyphae-forming sporangia and early become very dark in colour. The hyphal walls are much thicker and tests with iodine indicate the contents of the cells to be richer in glycogen than in the case of the sporangial hyphae. A very manifest protoplasmic streaming occurs during the development of the gametes in marked contrast to the vacuolation and septation which takes place in the development of the sporangiophores.

The early appearance of the black product in the zygosporic tufts is probably an important index of the differing metabolism of the hyphae of these tufts. The product appears first in the protoplasm and is deposited in the thickened walls of the hyphae, being especially abundant in the wall of the zygospore. Although a certain amount of browning occurs, this dark coloured substance does not appear in the same quantity in the sporangiophore, and it seems likely that in the development of the zygosporic branches a tyrosinase-like reaction resulting in the appearance of melanins is much more active than in the sporangial development. This question is being further investigated.

Concluding Remarks.

In the determination of the transition from purely vegetative growth to the development of either type of reproductive structure in *Sporodinia*, the primary factors appear to be the internal metabolic changes associated with a diminution of growth. The changes envisaged are, up to a point, common to both types of reproductive body and are manifested by the development of aerial hyphae. From this stage the course of the subsequent metabolic processes and the consequent morphological development are determined by the nature of the medium and the degree of humidity of the air over this*. If the medium has been relatively concentrated in carbohydrate and the humidity over the culture is high, then zygosporic tufts are developed. If, on the other hand, the concentration

* A definite sequence of physico-chemical causation is here thought of rather than the stimulus effects postulated earlier by Klebs.

of carbohydrate in the medium is relatively low and the humidity is below 80 per cent. then sporangial tufts arise. It is obvious that, in the first case, the thickened walls of the zygosporic hyphae and the richness of these in glycogen is correlated with the high concentration of sugars in the medium, surplus carbohydrates accumulating in the hyphae in the form of condensation products such as glycogen and wall substances. The appearance of melanins is less easily explained, but it is hoped that further work on the nitrogen metabolism of *Sporodinia* will throw light on this question.

It may here be suggested, however, that the relative exhaustion of the medium in nitrogen is probably the primary cause of the diminution in growth. This may be responsible for the changed direction of metabolism which is undoubtedly seen in the reproductive phase of the fungus.

The further analysis of the questions raised in a preliminary way in this paper is being carried forward, and it appears not unlikely that definite relationships between the metabolic processes and the different structures arising during the reproduction of *Sporodinia* may be established.

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ADDITIONAL RECORDS OF CTENOMYCES SERRATUS EIDAM.

By R. W. Marsh, B.A., Research Assistant in Mycology in the University of Manchester.

Ctenomyces serratus Eidam was found in August, 1922, in three pots at the Botanic Garden, Cambridge. Two of the pots contained pine seedlings, the other, a young *Cistus*. Four

months previously these plants had undergone root inoculation with *Roesleria hypogoea* Thüm. et Pass. When examined, the pines were dead; the *Cistus* apparently healthy.

In December, 1922, root inoculations were made on rose, *Quercus alba* and *Cotoneaster* sp. with cultures of *Roesleria* derived from that previously used. In June, 1923, examination showed *Ctenomyces* present on all the inoculated roots.

In all the cases mentioned the *Ctenomyces* fructifications occurred clustered round the point of inoculation on the exterior of the root or in the soil in the immediate neighbourhood. The ascus stage only was found.

The pots contained ordinary potting soil, and as far as could be ascertained no particles of feathers were present, neither had any opportunity arisen for contact with feathers to take place.

In September, 1923, *Ctenomyces* was found in Queen's Cottage Grounds at the Royal Botanic Gardens, Kew, from whence it had been previously recorded by Professor E. S. Salmon. The fungus occurred in an area about 1 foot across beneath a chestnut tree. At this point the soil was covered with leaves and twigs more or less decayed, mixed with which were rotted feathers. The ascus fructifications were scattered indiscriminately through this *débris*, and occurred also in the uppermost 2 or 3 inches of soil. Search was made for the fungus at the same spot in June, 1924, but without success.

Single spore cultures were started from the ascospores of the Cambridge material, but as might be expected no indication has yet (1925) been found that *Roesleria* and *Ctenomyces* were in any but a chance association. From these cultures, however, conidiophores of two types (as figured by von Eidam) have originated—single hyphae, and clusters of hyphae repeatedly branched at right angles—the conidia being borne laterally in both types. The genetic connection of these conidial forms with the ascus stage has thus been established.

Von Eidam also describes a perennating stage in which the fungus forms a compact woolly mycelium bearing long, stiff, barbed *krallenhaken*, which, in his view, are of use in dispersing the fungus. This stage has not been seen in the course of these observations.

In culture, *Ctenomyces* has been found to grow on a variety of substrata. Vigorous cultures have resulted on Dox's agar, horse-dung agar, starch-asparagin-glucose agar, raisin gelatine, beerwort gelatine, plum-wood blocks and sterilised soil. On clean sterilised feathers growth was extremely meagre but the fungus grew well on feathers that were mixed with soil.

Von Eidam, Dangeard and Grove all describe the fungus as occurring on dirty and decaying feathers. Grove mentions that

it also occurs on soil. The material found at Cambridge occurred in the complete absence of feathers, a phenomenon previously recorded by Miss Lorrain Smith, who describes a gathering of *Ctenomyces* by the Rev. W. Eyre in Hampshire on decaying beech and other leaves. The same author refers to a fungus collected by Currey in 1854, upon fragments of dead leaves and sticks on very moist ground in woods, for which he suggested the new generic name of *Arthroderma*. It was subsequently named *Arthroderma Curreyi* by Berkeley and appears in Saccardo as *Illosporium Curreyi* (Berk.) Sacc. From Currey's figures it seems extremely probable that this fungus was *Ctenomyces serratus*.

Mr Ramsbottom informs me that Mr St John Marriott found the fungus on cabbage roots at Woolwich and that he himself has found it on roots of grasses at the edge of a herbaceous border at Richmond, Surrey.

From these records it would appear that the specialisation of *Ctenomyces* is not as strict as is usually stated. The cultural work would suggest that in the cases where the fungus is found on feathers it is there essentially as an epiphyte deriving little or no nourishment from them.

I have to express my gratitude to Miss E. M. Wakefield for supplying me with certain references, and my best thanks to Mr F. T. Brooks for his interest and help in these observations.

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NOTE.

CLADOCHYTRIUM MYRIOPHYLLI ROSTR.—A NEW BRITISH RECORD.

The material of the fungus, described briefly in this note, was collected by the late Dr R. C. Davie prior to 1915, and handed over to me for examination by Dr Malcolm Wilson. This fungus, which occurs on *Myriophyllum verticillatum* was certainly obtained in Scotland and it is very probable that it was from some part of Perthshire.

Cladochytrium Myriophylli was first described by Rostrup (Myk. Medd. IX, *Bot. Tidsskr.* XXVI, p. 305, 1904–5) and the life-

history was later worked out by Ferdinandsen and Winge and recorded in the same Danish *Journal* (XXIX, p. 305, 1908–9). Vestergren has transferred the species to the genus *Physoderma*.

In the Scottish material thick brownish tumours occurred on the stems. Underneath the brownish patches and distributed in the intercellular spaces of the parenchyma of the host were numerous big ellipsoidal to spherical spores, possessing thick brownish yellow walls. The size of the spores measured on the average about 30 μ across. In some cases, lying alongside the resting spores, were the remains of a large thin-walled cell, with appendages. These appendages are very probably the hyphal attachments and the cell itself is looked upon by some as the antheridium. The resting spores are filled with large globules of yellow oil.

Cladochytrium Myriophylli has not been previously recorded in Britain, but the allied species, *Physoderma Menyanthis* de Bary, is not uncommon and is found in East Lothian and other localities.

JOHN S. L. WALDIE.

Mycological Dept., University of Edinburgh.

PROCEEDINGS.

MEETING. UNIVERSITY COLLEGE, LONDON. *24th January.*

Miss E. M. Blackwell. An outline of the life history of *Phytophthora cactorum* Schroet.
Mr H. R. Briton-Jones. "Bark-Canker" and "Die-Back" of Fruit trees.
Mr J. Ramsbottom. Fragmenta Mycologica II.
Prof. E. S. Salmon. The Epidemic Appearance in England in 1924 of a "Downy Mildew" of the Hop.

MEETING. UNIVERSITY COLLEGE, LONDON. *21st March.*

Miss E. Green. The development of *Zygorhynchus*.
Mr W. F. Hanna. Sex in the genus *Coprinus*.
Mr. J. Ramsbottom. Fragmenta Mycologica III.
Dr M. C. Rayner. Sectoring in cultures of *Phoma radicis-Callunae* Rayn.
Miss A. L. Smith. 1. Notes on Myxobacteriaceae. 2. Templeton's drawings of Fungi and Lichens.

SPRING FORAY, TINTERN. *24th—28th April.*

SPRING FORAY FOR LONDON STUDENTS, BOX HILL. *9th May*

PHYTOPATHOLOGICAL MEETING, CAMBRIDGE. *4th July.*

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122. Green, Col. C. Theodore, A.M.S., M.R.C.S. (Eng.), L.R.C.P. (Lond.), F.L.S., 31, Shrewsbury Road, Birkenhead. (1901.)
123. Green, Miss E., 9, Brunswick Square, London, W.C. (1925.)
124. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey. (1917.)
125. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, S.E. 18. (1913.)
126. Gwynne-Vaughan, Professor Dame Helen, D.Sc., LL.D., F.L.S., 93, Bedford Court Mansions, London, W.C. 1. (1906.)
127. Haas, Mr P., D.Sc., Ph.D., F.C.S., University College, Gower Street, London, W.C. 1. (1921.)
128. Hadden, Mr Norman G., Underway, West Porlock, Somerset. (1911.)
129. Hanna, Mr W. F., M.Sc., University of Alberta, Edmonton, Alberta, Canada. (1925.)
130. Hansford, Mr C. G., B.A., Microbiologist, Department of Agriculture, Jamaica. (1921.)
131. Hare, Mr J. G., Molteno Institute of Parasitology, Cambridge. (1924.)
132. Harris, Mr R. V., B.Sc., Research Station, East Malling, Kent. (1924.)
133. Harvard University Library, Cambridge, Mass., U.S.A. (1923.)
134. Harvey, Mrs Cecily D., Barwick in Elmet Rectory, nr. Leeds. (1910.)
135. Hasluck, Miss I. E., Green Hill Park, New Barnet, Herts. (1922.)
136. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1. (1913.)

137. Hemmi, Mr Takewo, Phytopathological Institute, Dept. of Agriculture, Kyoto Imperial University, Kyoto, Japan. (1923.)
138. Henry, Professor A., M.A., L.R.C.P. (Edinb.), M.R.I.A., V.M.H., College of Science, Upper Merrion Street, Dublin. (1925.)
139. Hildyard, Mr F. W., 14, Lambridge, Bath. (1913.)
140. Hiley, Mr Wilfred E., M.A., F.L.S., Research Institute, School of Forestry, Oxford. (1913.)
141. Hoare, Mr A. H., 111, Blenheim Gardens, Wallington, Surrey. (1922.)
142. Hoggan, Miss I. A., 28 A, Leinster Terrace, Lancaster Gate, London, W. 2. (1923.)
143. Holden, Mr H. S., D.Sc., F.L.S., Botanical Department, University College, Nottingham. (1923.)
144. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii. (1920.)
145. Horne, Mr A. S., D.Sc., F.L.S., F.G.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
146. Howard, Mr H. J., F.R.M.S., "Lingfield," 6, College Road, Norwich. (1918.)
147. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898.)
148. Humphrey, Mr C. J., Laboratory of Forest Pathology, Old Soils Building, University of Wisconsin, Madison, Wis., U.S.A. (1921.)
149. Hunter, Mr C., M.Sc., Botanical Department, The University, Bristol. (1921.)
150. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth. (1921.)
151. Hyde, Mr H. A., B.A., National Museum of Wales, Cardiff.
152. Imperial College of Tropical Agriculture, Trinidad, B.W.I. (1921.)
153. Iowa, Library, State University of, Iowa City, Iowa, U.S.A. (1923.)
154. Issatchenko, Professor B. L., Directeur du Jardin Botanique, Petrograd, Russia. (1923.)
155. Jaczewski, Professor Arthur de, Director, Institute of Mycology, and Phytopathology, Perspective Anglaise 29, Petrograd, Russia. (1922.)
156. John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1924.)
157. Johnson, Mr J. W. Haigh, M.Sc., F.I.C., F.L.S., Walton, nr. Wakefield. (1919.)
158. Johnstone, Mr R. B., 134, Cambridge Drive, Glasgow. (1908.)
159. Jones, Mr G. H., B.A., Mycologist, Department of Agriculture, Ibadan, S. Nigeria. (1922.)
160. Jones, Mr Robert Fowler, Trinity House, Denton Road, Ilkley, Yorkshire. (1918.)

161. Jørstad, Mr Ivar, Statsmykolog, Botanisk Museum, Christiania, Norway. (1923.)
162. Keef, Miss Phoebe, Mortimer Lodge, Wimbledon Park, London, S.W. 17. (1921.)
163. Keilin, Dr D., Molteno Institute of Parasitology, Cambridge. (1922.)
164. Keissler, Dr Karl, Direktor d. Botanische Abteilung, Naturhistorisches Museum, Burgring 7, Wien 1/1. (1924.)
165. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921.)
166. Kendall, Miss O., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1921.)
167. Kew, The Library, Royal Botanic Gardens. (1921.)
168. Kidd, Mrs Franklin, The Botany School, Cambridge. (1919.)
169. Kirby, Mr E. E., B.A., Grafton House, Oxford Street, Norwich. (1924.)
170. Knight, Mr H. H., M.A., The Lodge, All Saints' Villas, Cheltenham. (1914.)
171. Knowles, Miss M. C., M.R.I.A., Natural History Museum, Dublin. (1925.)
172. Krieger, Mr L. C. C., 2114, N. Calvert Street, Baltimore, Md., U.S.A. (1921.)
173. Kulkarni, Mr G. S., M.Ag., Assistant Professor of Mycology, Agricultural College, Poona, India. (1922.)
174. Lampitt, Mr L. H., D.Sc., F.I.C., 33, Roxborough Park, Harrow-on-the-Hill, Middlesex. (1925.)
175. Latter, Miss Joan, Botanical Department, King's College, Strand, London, W.C. 2. (1923.)
176. Leicester, The Museum, City of Leicester. (1923.)
177. Lewis, Professor F. J., D.Sc., University of Alberta, Edmonton, Alberta, Canada. (1924.)
178. Line, Mr James, M.A., School of Agriculture, Cambridge. (1921.)
179. Linnean Society, The, Burlington House, Piccadilly, London, W. 1. (1919.)
180. Lloyd, Mr C. G., The Lloyd Library and Museum, 224, West Court Street, Cincinnati, Ohio, U.S.A. (1907.)
181. Lowndes, Mr A. G., M.A., Marlborough College, Marlborough, Wilts. (1922.)
182. MacCullum, Mrs B. D., M.A., D.Sc., F.L.S., c/o Professor MacCallum, Department of Pathology, University of Melbourne, Melbourne, Victoria, Australia. (1921.)
183. Mackenzie, Miss A. D., Research Station, East Malling, Kent. (1921.)
184. Mackenzie, Mr D., Afton, Busby, N.B. (1900.)
185. Maire, M. René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algers, Algeria. (1907.)

186. Maitland, Mr T. D., Government Botanist, Department of Agriculture, Kampala, Uganda. (1916.)
187. Maltby, Mr G. C., 14, Northwick Road, Evesham.
188. Marmont, Mr Basil P., Windsoredge House, Inchbrook, nr. Woodchester, Gloucestershire. (1908.)
189. Marriott, Mr St John, 37, Owenite Street, Abbey Wood, London, S.E. 2. (1920.)
190. Marsh, Mr R. W., B.A., Botanical Department, The University, Manchester. (1923.)
191. Mason, Mr E. W., M.A., M.Sc., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
192. Mason, Mrs E. W., Suffield House, Paradise Road, Richmond, Surrey. (1922.)
193. Mason, Mr F. A., F.R.M.S., M.S.P.A., The Laboratory, 3, Queen's Square, Leeds. (1912.)
194. Mason, Mr F. R., Assistant Mycologist, Department of Agriculture, Kuala Lumpur, Federated Malay States. (1921.)
195. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh. (1921.)
196. McDonald, Mr J., B.Sc., Mycologist, Department of Agriculture, Nairobi, Kenya Colony. (1923.)
197. McDougall, Professor W. B., University of Illinois, Urbana, Ill., U.S.A. (1921.)
198. McFarland, Mr Frank T., Ph.D., Department of Botany, University of Kentucky, Lexington, Ky., U.S.A. (1924.)
199. McIver, Mr D. G., Regent Court, Headingley, Leeds. (1924.)
200. McLean, Professor R. C., M.A., D.Sc., F.L.S., Botanic Department, University College, Cardiff. (1922.)
201. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
202. Melvill, Mr J. Cosmo, M.A., D.Sc., F.L.S., Meole Brace Hall, Shrewsbury. (1922.)
203. Menzies, Mr James, 117, Scott Street, Perth. (1917.)
204. Meulenhoff, Dr J. S., President, Dutch Mycological Society, Diezerstraat, Zwolle, Holland. (1921.)
205. Millard, Mr W. A., B.Sc., The Agriculture Department, The University, Leeds. (1924.)
206. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
207. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
208. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
209. Moore, Miss E. S., Ph.D., c/o the Secretary, Dept. of Agriculture, Pretoria. (1923.)
210. Moore, Mr W. C., The Botany School, Cambridge. (1922.)
211. Morris, Mr L. E., The Shirley Institute, Didsbury, Manchester. (1924.)

212. Moss, Professor C. E., M.A., D.Sc., F.R.G.S., F.L.S., The University, P.O. Box 1176, Johannesburg, S. Africa. (1923.)
213. Mottram, Miss W. E., B.Sc., Horton Lane, Epsom, Surrey. (1925.)
214. Mundkur, Mr B. B., M.A., Cotton Research Laboratory, Government Farm, Dharwar, India. (1924.)
215. Murphy, Mr P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Plant Diseases Division, College of Science, Dublin. (1924.)
216. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea. (1921.)
217. Murrell, Major Percy J., O.B.E., F.R.M.S., "Littlecroft," Orpington, Kent. (1923.)
218. Muskett, Mr A. E., Queen's University, Belfast, N. Ireland. (1923.)
219. Nagpur, The Mycologist to the Government, C.P., India. (1924.)
220. Nattrass, Mr R. M., B.Sc. (Agric.), Research Station, Long Ashton, Bristol. (1925.)
221. Nebraska, The Library, University of, Lincoln, Nebraska, U.S.A. (1924.)
222. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Zoomweg 10, Wageningen, Holland. (1920.)
223. Newcastle-upon-Tyne, Literary and Philosophical Society, c/o H. Richardson, Librarian. (1902.)
224. Newman, Mr Leslie, M.A., F.I.C., F.L.S., Dip. Agr. Cantab., St Catharine's College, Cambridge. (1906.)
225. Newton, Mr W. C. F., B.Sc., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1922.)
226. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
227. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)
228. Noel, Miss E. F., F.L.S., 37, Moscow Court, Queen's Road, London, W. 2. (1913.)
229. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
230. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
231. O'Connor, Mr P., B.Sc., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
232. Ogilvie, Mr L., M.A., M.Sc., Department of Agriculture, Agricultural Station, Paget East, Bermuda. (1922.)
233. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
234. Oldham, Mr C. H., Ivy Dene, Chandler's Ford, Southampton. (1923.)

235. Ontario Agricultural College Library, Guelph, Ontario, Canada. (1920.)
236. Osborn, Professor T. G. B., M.Sc., Adelaide University, Adelaide, South Australia. (1910.)
237. Overeem, Dr C. van, c/o Martinus Nijhoff, Lange Voorhout 9, 's-Gravenhage, Holland. (1920.)
238. Page, Miss W. M., M.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1. (1921.)
239. Pan, Mr T. C., M.B., Ch.B., Avondale, Lenzie, Glasgow. (1925.)
240. Parke, Davis & Co., Librarian, Research Department, Detroit, Mich., U.S.A. (1920.)
241. Paul, The Very Rev. David, D.D., LL.D., 53, Fountainhall Road, Edinburgh. (1899.)
242. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex. (1918.)
243. Peacock, Dr H. G., The Lawn, Torquay. (1896.)
244. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
245. Peck, Mr A. E., Tosti, 20, Avenue Road, Scarborough. (1918.)
246. Peklo, Dr Jaroslav, Professor of Applied Botany, Bohemian Technical University, Charles Square, Prague 11. (1924.)
247. Peltereau, M. E., Notaire honoraire, Vendôme, Loir-et-Cher, France. (1909.)
248. Perthshire Society of Natural Science, c/o James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
249. Petch, Mr T., B.A., B.Sc., 24, Grove Avenue, Norwich. (1911.)
250. Pethybridge, Mr G. H., Ph.D., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
251. Philadelphia, The Academy of Natural Sciences of, Logan Square, Philadelphia, U.S.A. (1925.)
252. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 20. (1923.)
253. Phillips, Mr J. F., Research Officer, Forest Research Station, Deepwalls, Knysna, South Africa. (1921.)
254. Plowright, Mr Charles Tertius Maclean, B.A., M.B., King Street, King's Lynn. (1901.)
255. Potter, Rev. Professor M. C., Sc.D., M.A., F.L.S., Corley Cottage, York Avenue, New Milton, Hants. (1896.)
256. Potts, Mr George, Benthall House, Broseley, Salop. (1910.)
257. Povah, Professor A. H., 9, Fisk Hall, Northwestern University, Evanston, Ill., U.S.A. (1924.)
258. Preston, Mr N. C., B.Sc., Harper Adams Agricultural College, Newport, Salop.
259. Pretoria, South Africa, The Chief, Division of Botany, Department of Agriculture. (1922.)

260. Priestley, Professor J. H., D.S.O., B.Sc., F.L.S., Botanical Department, The University, Leeds. (1912.)
261. Priestley, Mrs Marion E., 2, Balmoral Terrace, Shaw Lane, Headingley, Leeds. (1919.)
262. Pusa, Imperial Mycologist, Imperial Agricultural Research Institute, Pusa, Bihar, India. (1921.)
263. Ramsbottom, Mr J., O.B.E., M.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7. (1910.)
264. Rayner, Mr J. F., Swaythling, Southampton. (1902.)
265. Rayner, Miss M. Cheveley, D.Sc., Bedford College, Regent's Park, London, N.W. 1. (1921.)
266. Rea, Mrs E. A., 6, Barbourne Terrace, Worcester. (1896.)
267. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Ireland. (1920.)
268. Rea, Miss Violet, 6, Barbourne Terrace, Worcester. (1921.)
269. Reichert, Dr Israel, Plant Pathologist, Palestine Zionist Executive Agricultural Experiment Station, Tel-Aviv, Palestine. (1924.)
270. Rhind, Mr Donald, B.Sc., Mycologist, Agricultural College, Mandalay, Burma. (1922.)
271. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
272. Richards, Mr R. M., M.B.E., A.R.C.S., F.L.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements. (1915.)
273. Ridler, Miss W. F. F., M.Sc., Botanical Department, The University, Bristol. (1921.)
274. Roberts, Mrs A. W. Rymer, The End House, Fulbrook Road, Cambridge. (1920.)
275. Robinson, Mr Wilfred, D.Sc., Department of Botany, University of Manchester. (1923.)
276. Robson, Mr R., M.Sc., F.Z.S., Writtle, Chelmsford, Essex. (1914.)
277. Rolfe, Mr F. W., Colonial and Indian Collections, Imperial Institute, London, S.W. 7. (1923.)
278. Rolfe, Mr R. T., F.I.C., 76, Spenser Road, Bedford. (1924.)
279. Roper, Miss Ida M., F.L.S., 4, Woodfield Road, Redland, Bristol. (1921.)
280. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
281. Rushton, Mr W., A.R.C.S., D.I.C., St Thomas's Hospital, Medical School, Albert Embankment, London, S.E. 1. (1914.)
282. Rutgers College and State University of New Jersey, Library, New Brunswick, New Jersey, U.S.A. (1922.)
283. Ryan, Mr G. M., F.L.S., 35, Ladbroke Gardens, London, W. 11. (1923.)

284. St Paul, Minn., U.S.A., The Library, Department of Agriculture, University Farm. (1920.)
285. Salisbury, Mr E. J., D.Sc., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1921.)
286. Salmon, Mr E. S., F.L.S., South Eastern Agricultural College, Wye, Kent. (1922.)
287. Sampson, Miss K., B.Sc., Economic Botanist, Plant Breeding Station for Wales, University College, Aberystwyth, N. Wales. (1920.)
288. Samuel, Mr Geoffrey, University of Adelaide, South Australia. (1923.)
289. Sanderson, Mr A. R., F.L.S., Research Laboratory (Rubber Growers' Association), Petaling, Federated Malay States. (1921.)
290. Schinz, Professor Dr Hans, Botanical Garden and Museum, Zurich, Switzerland. (1921.)
291. Science Library (The), South Kensington, London, S.W. 7. (1924.)
292. Scott, Mr W. Murray, Wakemills, Haslemere, Surrey. (1921.)
293. Scott, Mr W. W., 23, Wood Lane, Highgate, London, N. 6. (1922.)
294. Searle, Mr G. Odell, B.Sc. (Agric.), Research Botanist, Linen Industry Research Association, Glenmore House, Lambeg, Lisburn, Ireland. (1920.)
295. Sharpe, Mr C. J., Brambleside, Manor Road, Sidcup. (1905.)
296. Sharples, Mr A., A.R.C.S., D.I.C., Mycologist, Dept. of Agriculture, Kuala Lumpur, F.M.S. (1924.)
297. Shaw, Mr F. J. F., D.Sc., A.R.C.S., F.L.S., Imperial Agricultural Research Institute, Pusa, Bihar, India. (1920.)
298. Small, Mr W., M.B.E., Ph.D., M.A., B.Sc., Royal Botanic Gardens, Peradeniya. (1915.)
299. Smith, Mr Alexander, The Botany School, Cambridge. (1924.)
300. Smith, Mr F. E., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1922.)
301. Smith, Miss K. E., 64, Coton Road, Nuneaton. (1913.)
302. Smith, Mr Noel J. G., 9, Braidburn Crescent, Edinburgh. (1924.)
303. Smith, Miss S. Somerford, 6, Barbourne Terrace, Worcester. (1923.)
304. Smith, Mr Thomas, 31, Granby Road, Stockport. (1918.)
305. Solberg, Miss Louise, Kobbervik Drammen, Norway. (1923.)
306. South London Botanical Institute, Tulse Hill, Herne Hill, London, S.E. 24. (1921.)
307. Southwell, Mr Herbert, A.R.C.S., 158, Lincoln Road, Peterborough. (1923.)
308. Stakman, Professor E. C., University of Minnesota, Minneapolis, Minn., U.S.A. (1922.)

309. Stansfield, Miss O. P., M.Sc., Milton Mount College, Crawley, Sussex. (1922.)
310. Stationery Office, H.M., Superintendent of Publications, Book Department, Westminster, S.W. 1. (1920.)
311. Stelfox, Mrs A. W., Mayfield, Clareville Road, Rathgar, Dublin. (1925.)
312. Stirrup, Mr H. H., M.Sc., Midland Agricultural College, Sutton Bonington, Loughborough. (1922.)
313. Storey, Mr H. H., B.A., Natal Herbarium, Durban, South Africa. (1922.)
314. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., 110, Brackenbury Road, Moor Park, Preston. (1914.)
315. Swansea Scientific and Field Naturalists' Society, c/o Alan Stuart, Esq., M.Sc., University College, Singleton, Swansea. (1924.)
316. Swanton, Mr E. W., A.L.S., Brockton, Haslemere, Surrey. (1899.)
317. Swedish Academy of Sciences, Royal, Stockholm, Sweden. (1919.)
318. Sydney, Australia, The Librarian, University of. (1922.)
319. Tabor, Mr Richard John, B.Sc., F.L.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1914.)
320. Tagg, Mr H. F., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
321. Tandy, Mr Geoffrey, 210, Gloucester Terrace, Hyde Park, London, W. 2. (1925.)
322. Taylor, Miss Beatrice Katherine, 98, Cheyne Walk, Chelsea, London, S.W. 3. (1910.)
323. Taylor, Mr G. Crosbie, "The Garden," 20, Tavistock Street, Covent Garden, London, W.C. 2. (1924.)
324. Thomas, Mr H. Hamshaw, M.B.E., M.A., The Botany School, Cambridge. (1910.)
325. Toronto, University of, Librarian, Toronto, Canada. (1919.)
326. United States, Department of Agriculture. (1907.)
327. Vines, Professor S. H., M.A., D.Sc., F.R.S., F.L.S., Langstone, Exmouth, Devon. (1915.)
328. Wadham, Mr S. M., M.A., The Botany School, Cambridge. (1922.)
329. Wager, Mr H., D.Sc., F.R.S., F.L.S., 4, Bank View, Chapel Allerton, Leeds. (1896.)
330. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew. (1911.)
331. Waldie, Mr J. S. L., Royal Botanic Garden, Edinburgh. (1925.)
332. Wallis, Mr A., Westacre, Station Road, Kettering. (1921.)
333. Ware, Mr W. M., M.Sc., South-Eastern Agricultural College, Wye, Kent. (1924.)

334. Washington, The Library, State College of, Pullman, Wash., U.S.A. (1924.)
335. Watson, Mr W., D.Sc., A.L.S., Taunton School, Taunton. (1923.)
336. Wayman, Mr H. W. B., 4, Vernon Place, Bloomsbury, London, W.C. 1. (1923.)
337. Welsford, Miss E. J., M.B.E., F.L.S., Mycologist, Department of Agriculture, Zanzibar. (1924.)
338. Westerdijk, Professor Johanna, Javalaan 4, Baarn, Holland. (1923.)
339. Weston, Mr W. A. R. Dillon, B.A., Dip. Ag., School of Agriculture, Cambridge. (1923.)
340. Whetzel, Professor H. H., M.A., New York State College of Agriculture, Cornell University, Ithaca, New York, U.S.A. (1914.)
341. Whitaker, Mr F. Owen, 89, Eccleston Square, London, S.W. 1. (1921.)
342. Whitehead, Mr T., A.R.C.S., University College of North Wales, Bangor. (1920.)
343. Williams, Professor J. Lloyd, D.Sc., F.L.S., Botanical Department, University College of Wales, Aberystwyth. (1921.)
344. Williamson, Mrs H. S., B.Sc., 3, Verulam Buildings, Gray's Inn, London, W.C. 1. (1921.)
345. Wilson, Mr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
346. Wiltshire, Mr S. P., M.A., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1920.)
347. Wiltshire, Mrs, 24, Lawn Crescent, Kew Gardens, Surrey. (1925.)
348. Winsor, Mr A. P., A.R.C.Sc.I., Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1. (1923.)
349. Wisconsin, The Library, University of, Madison, Wis., U.S.A. (1923.)
350. Wolf, Mr B. L., N.D.A., 55, Catharine Street, Salisbury. (1923.)
351. Wood, Mr N. J., The Cottage, Barcombe, nr. Lewes, Sussex. (1923.)
352. Woodward, Mr R. C., B.Sc., Advisory Mycologist, School of Rural Economy, Oxford. (1924.)
353. Woolhope, The Naturalists' Field Club, Hereford, c/o Mr C. S. Scobie, 2, Offa Street, Hereford. (1896.)
354. Worcestershire Naturalists' Field Club, c/o Mr F. T. Spackman, F.G.S., 190, Bath Road, Worcester. (1921.)
355. Wormald, Mr H., D.Sc., A.R.C.S., Research Station, East Malling, Kent. (1921.)

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct. 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX.

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

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